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**ENGINEERING TEST OF
GANTRY, LIGHTWEIGHT, AIRDROP RIGGING**

FINAL REPORT

BY

**TERRY W. PUCKETT, 1LT
NOVEMBER 1968**

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**YUMA PROVING GROUND
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DEPARTMENT OF THE ARMY
Headquarters, U.S. Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland 21005

AMSTE-BG

30 December 1969

SUBJECT: Final Report of Engineering and Service Test of Gantry, Lightweight, Airdrop Rigging, USATECOM Project Ncs. 4-5-7491-05 and 4-ES-655-035-001

Commanding General
US Army Materiel Command
ATTN: AMCRD-FS
Washington, D. C. 20315

1. References:

- a. Preliminary Report of Engineering Design Test of Modified Gantry, Lightweight, Airdrop Rigging, DA Project No. 1F141812D183, Task 22.
- b. Letter, AMSTE-BG, USATECOM, 20 December 1968, subject: Engineering Test Report of Gantry, Lightweight, Airdrop Rigging, RDT&E Project No. 1M141812D18322A, USATECOM Project No. 4-5-7491-05.

2. Approval Statement: Subject reports are approved except as stated herein.

3. Background:

a. Presently field units employ several types of materiel handling equipment not specifically designed for lifting loads being rigged for airdrop. To provide a single standard item, US Army Natick Laboratories developed the subject gantry system.

b. The complete gantry system has a lifting capacity of 35,000 pounds and consists of four "A" frame structures, two power packs and four accessory beams. This system can also be used as two separate lifting devices with each having a capacity of 17,500 pounds and consisting of two "A" frames, one power pack and two accessory beams. The gantries have an internal vertical clearance of 14 feet and a horizontal clearance of 12 feet. These clearances enable the gantry system to lift a nine foot high load five feet for placement onto transport vehicles ten feet wide.

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Each gantry is provided with two suspended lift hooks of adjustable height to accommodate the various locations of lift fittings on various type cargoes. These gantries are equipped with caster wheels, incorporating a locking and unlocking device to allow manual positioning at the rigging site or for relocating the gantries. Screwtype legs (feet) of sufficient size are provided on each gantry to enable lifting of loads on soft unprepared ground or on hard snow. The total weight of the 35,000-pound system is approximately 7,500 pounds and can be disassembled into component parts to permit manhandling by four personnel. The disassembled system is suitable for transport in air or ground vehicles.

c. The engineer design test of the gantry was completed in May 1966. At that time engineering tests (ET) were waived and the system was submitted for service testing. The results of this service test (ST) indicated that the gantry system was not suitable for Army use. As a result of the ST In-Process Review in December 1967, it was determined that the gantry system would be modified and would undergo both engineering and service tests.

d. The ET of the modified gantry was completed by Yuma Proving Ground in November 1968, the ST was completed by the US Army Airborne, Electronics and Special Warfare Board in September 1969 and the arctic winter service test is scheduled to be conducted beginning in September 1971.

4. Test Results:

a. The gantry met 34 of 50 requirements of the SDR. Six deficiencies and ten shortcomings were reported by the test agencies on the modified gantry system. After analysis and appropriate reclassification, no deficiencies and 15 shortcomings remain. One requirement of the SDR, operation and storage at -65°F, will be evaluated during the arctic winter service test.

b. Deficiencies - None.

c. Shortcomings (15)

(1) It was very difficult for four men to carry the power pack assembly and load it onto a military vehicle. However, if the hydraulic oil was drained from the power pack, the weight would be reduced by

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65 pounds and, at this reduced weight, the test item will meet the requirements of the SDR. Further, the draining of the hydraulic oil (No. 10 engine oil) is a simple operation.

(2) The draft technical manual 5-3950-205-14 for the gantry system was not clear, concise, or complete. Eighty-eight recommended changes to this manual were proposed, 80 are classified as administrative, seven recommend that an operator is within the operator's capability (now assigned to other than the gantry operator), and one recommends that gloves be worn when operating the gantry in the manual mode. All of the proposals can be incorporated into an updated manual without being verified by retesting, and this item can be maintained under field conditions.

(3) Auxiliary equipment required for lifting loads was not included with the test system. Since MB-2 tiedowns, FSN 1670-545-9063, were found to be adequate during this test program and are available within the supply system, the addition of MB-2 tiedowns to the test system is considered acceptable.

(4) Spare parts for the power pack engines were not available through normal supply channels at the service test agency. Since these 3-HP gasoline engines are military standard items with hydraulic pumps and control valves, the lack of spare parts within the supply system should not be considered as a failure of the test item to meet the technical specification.

(5) During the ST this system demonstrated a 90 percent reliability with a 90 percent confidence level of completing a daily mission. (Requirement - 95 percent) However, prior to the ST (during ET) the same system demonstrated the necessary capability of 95 percent reliability. Seven of the reported failures cited in the ST report (Appendix IV, Table 1) are not failures as defined in the SDR. These reported failures did not prevent the test system from completing its assigned mission and could be repaired by the operator with the tools and materials provided within 30 minutes. Revised reliability computations, utilizing the data from the ET and the revised data from the ST, are provided as Inclosure 1. These combined results indicate that the test item demonstrated a reliability of 94 percent with a 90 percent confidence level. This difference (one percent) between the requirement (95 percent) and that demonstrated (94 percent) by the test item is considered minor.

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(6) The remaining shortcomings were found in the areas of physical characteristics, maintenance, operational performance/technical characteristics and human factors.

d. The test agency stated (deficiency) that the test system/device is not capable of immediate effective employment. The revised approved technical characteristics stated that the assembly time for a device (17,500-pound capacity) must be less than one hour. This was demonstrated during the ST (actual 47 minutes). Although the parameter for assembly of the system was not defined in the revised technical characteristics, the assembly of the system did take 94 minutes.

e. The test item met the requirements for maintainability.

f. The test item is safe to operate; however, potential operational hazards are noted below in paragraph 4g.

g. During this test program the following improvements/actions are suggested relative to the test item.

(1) That hydraulic hose(s) or hydraulic fitting(s) not be repaired but replaced as necessary.

(2) The cable ends be soldered in lieu of being taped. Tape falls off the cable ends in a short period of time and the loose ends are exposed.

5. Conclusion: The gantry system is suitable for Army use under intermediate environmental conditions.

6. Recommendation: As many of the shortcomings as feasible be corrected.

FOR THE COMMANDER:

2 Incl
1. as
2. ST Report

/s/ William H. Hubbard
/t/ WILLIAM H. HUBBARD
Colonel, GS
Deputy Chief of Staff

AMSTE-BG

30 Dec 1969

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Lightweight, Airdrop Rigging, USATECOM Project Nos.
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Reliability Computations for
Engineering and Service Tests

1. BASIC DATA:

- a. Lift Cycles: 4102
- b. Number of Failures: 2
- c. Mission Day: 50 cycles

2. Computation of Point Estimate of Reliability:

- a. Computation of point estimate of Mean Time Between Failures (MTBF):

$$\text{MTBF} = \underline{\text{NT}}$$

$$\text{MTBF} = \frac{4102}{2} = 2051$$

MTBF = 2051 cycles or 5.56 mission days, where:

NT = Test duration in terms of lift cycles, and

= Number of failures

- b. Computation of Reliability:

$$R(x) = \frac{-x}{\text{MTBF}}$$

$$R(50) = \frac{-50}{2051}$$

$$R(50) = 2.73$$

$$R(50) = \frac{-024}{2.73}$$

R = .976 or 98 percent is a point estimate of reliability where:

R = Point estimate of reliability

x = One mission day = 50 cycles

= Natural log base = 2.73

MTBF = 2051 point estimate of Mean Time Between Failures

Inclosure 1

3. Computation of Reliability with 90 percent Confidence Level Assumed:

a. Computation of MTBF:

$$MTBF = \frac{2 x_T}{x^2,2 + 2}$$

$$MTBF = \frac{2(4102)}{x^2,1,2(2) + 2}$$

$$MTBF = \frac{8204}{10.645}$$

MTBF = 770 cycles where:

x_T = Test Duration = 41.2 cycles

= Number of Failures (2)

x^2 = Chi square factor (from Table H-3b,
AMCP 702-3) and is given by $100(1 - \alpha) \%$ = 90 percent confidence.

b. Computation of Reliability:

$$R(x) = \frac{-x}{MTBF}$$

$$R(50) = \frac{-50}{770}$$

$$R(50) = 2.73$$

$$R(50) = \frac{-0649}{2.73}$$

R(50) = .937 or 94 percent reliability at a 90 percent confidence level where:

R = Reliability

x = Mission Day = 50 cycles

= Natural log base = 2.73

MTBF = Mean Time Between Failures = 770 cycles

4. Results:

a. The test system demonstrated a point estimate reliability of 98 percent.

b. The test system demonstrated a reliability of 94 percent with a confidence level of 90 percent.

USATECOM PROJECT NO. 4-5-7491-05

ENGINEERING TEST OF
GANTRY, LIGHTWEIGHT, AIRDROP RIGGING

TEST REPORT

BY

TERRY W. PUCKETT, 1LT
NOVEMBER 1968

YUMA PROVING GROUND
YUMA, ARIZONA

ABSTRACT

The engineer test of the Gantry, Lightweight, Airdrop Rigging, was conducted by Yuma Proving Ground from 20 May 1968 to 30 August 1968.

The purpose of the test was to determine the suitability of the test gantry for service testing.

All testing was conducted under natural environmental conditions. The approved technical characteristics of the test item were used as criteria to determine test item reliability. The power pack was too heavy for four men to carry and load onto a military vehicle (deficiency). The manual chain hoists corroded, the winch broke, and the hydraulic cylinder leaked oil (shortcomings).

It was concluded that the shortcomings were readily correctible, that the Gantry, Lightweight, Airdrop Rigging, is suitable for lifting loads up to 17,500 pounds when used as a device and 35,000 pounds when used as a system. It was recommended that the Gantry, Lightweight, Airdrop Rigging be subjected to service testing.

FOREWORD

Yuma Proving Ground was responsible for test execution, and preparation of the test report.

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SECTION 1. INTRODUCTION

1.1 BACKGROUND

In rigging and preparing airdrop loads, field units presently must employ several types of materials handling equipment such as mobile warehouse and rough-terrain forklift vehicles, heavy ordnance wreckers, construction cranes, and field fabricated A-frame gantries with manually operated hoists to accomplish necessary lifting. These devices are inadequate for rigging loads up to the required weight of 35,000 pounds and are not readily available for use at remote outloading sites.

To remedy this situation, an SDR was approved in July 1964 for a Gantry, Lightweight, Airdrop Rigging (GLAR) to provide a single item with a wide range lifting capability to replace the various materials handling equipment now in use (Ref 4, App VI).

A prototype gantry was designed and fabricated, and testing was initiated at U.S. Army Natick Laboratories (USANLABS) on 1 November 1965. The prototype gantry was unsatisfactory from the viewpoint of safety and human factors engineering.

Testing of a redesigned and modified gantry was resumed by USANLABS on 15 March 1966. This engineer design test was completed on 30 May 1966. At that time, it was recommended that the gantry be submitted for service testing (Ref 2, App VI).

Engineering tests on the GLAR were waived. The U.S. Army Airborne, Electronics and Special Warfare Board (USAAESWBD) conducted a service test of the GLAR at Fort Bragg, North Carolina, from 9 January through 20 April 1967. Because the GLAR did not meet several requirements of the SDR, the service test was terminated prior to completion. The USAAESWBD recommended that the Gantry, Lightweight, Airdrop Rigging be considered not suitable for Army use and that consideration be given to the development of a device employing a lifting means which would eliminate the excessive maintenance and training requirements.

As a result of a Pre-In-Process-Review Conference on 2 November 1967 and a formal In-Process-Review Meeting on 6 December 1967, it was decided that the gantry should be modified and submitted to USATECOM for conduct of engineering and service tests beginning 1 April 1968. Yuma Proving Ground was designated to conduct the engineering tests.

1.2 DESCRIPTION OF MATERIEL

The gantry device (two gantries, Fig. 1) has a lifting capacity of 17,500 pounds and consists of two A-frame structures and a power pack. The gantry system (four gantries, Fig. 2) can provide a lift capability of 35,000 pounds. Each gantry has a clearance of 14 feet vertically and 12 feet horizontally, to allow lifting 9-foot-high loads up to 5 feet for placement onto transport vehicles 10 feet wide.



FIGURE 1. Two gantry devices lifting separate loads.



FIGURE 2. One gantry system lowering 35,000-pound load onto aircraft loader.

The total weight of the 17,500-pound capacity gantry device, suitable for both mechanical and manual operation, is approximately 3840 pounds. Disassembly into component parts is possible to permit manhandling.

Each power pack consists of the standard military gasoline engine with hydraulic pump and control and safety valves. Valves are arranged so that the gantries may be operated individually or in pairs. Lifting is achieved by a combination of two hydraulic cylinders with a pulley and cable arrangement on each gantry.

Gantries are equipped with caster wheels to allow manual positioning at rigging sites. Adjustable leveling feet are provided for support during lifting. Screw-type legs are raised and lowered by reversible ratchet wrenches on the gantries. Feet are of sufficient size to enable lifting on soft, unprepared ground surfaces.

Hand operated winches are provided for manual erection of the gantries. Also, manually operated chain hoists are included for lifting of the load in the event of power failure or as the only means of lifting.

Components of the disassembled system are suitable for transport in Army ground vehicles and aircraft.

1.3 OBJECTIVE

To determine the technical performance and safety characteristics of the gantry in accordance with the SDR and the advanced data package.

1.4 SUMMARY OF RESULTS

a. The Gantry, Lightweight, Airdrop Rigging, had the following deficiency and shortcomings:

(1) Deficiency. The power pack was too heavy for four men to carry and to load onto a military vehicle (Para. 2.2.3 and App III).

(2) Shortcoming. The manual chain hoist chains corroded while exposed to the desert environment (Para. 2.2.3 and App III).

(3) Shortcoming. A wrench lever would not lock and had to be held in position so that the baseplate could be lowered (Para. 2.3.4 and App III).

(4) Shortcoming. The hydraulic oil cylinders were seeping oil which could not be stopped (Para. 2.4.3 and App III).

b. The following safety hazards, not covered in the safety criteria established by the USAAESWBD, were encountered:

(1) Cable ends of the winch hoist cable are clamped and the loose ends taped. After 3 or 4 weeks the tape falls off and the wire cable is exposed.

(2) Lifting loads with the manual chain hoist for 1 hour will cause blisters and open wounds on a man's hands (Para. 2.3.4d and App III).

(3) Shipping tape can become wedged between the winch hoist handle washer and the winch hoist causing the safety brake to slip (App III).

(4) When the angle from the accessory beam center fitting to the load connection point exceeds 3.6 degrees it is possible for the cable to jump out of the sheave when lifting the load. The load will drop approximately 8 inches when this occurs (Para. 2.5.3b).

(5) If failure occurs within the area of the hydraulic hose and the fittings located between the flow control valve and the cylinder, the load will fall. No attempt should be made to repair the referenced hose or flare the flange portions of the swivel nuts (Para. 2.5.3 and 2.5.4).

1.5 CONCLUSIONS

- a. The above deficiencies and shortcomings are readily correctible.
- b. The Gantry, Lightweight, Airdrop Rigging, is suitable for lifting loads up to 17,500 pounds when used as a device and 35,000 pounds when used as a system.

1.6 RECOMMENDATIONS

The Gantry, Lightweight, Airdrop Rigging be subjected to service testing.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

The Gantry, Lightweight, Airdrop Rigging, hereafter referred to as the test item, was tested by Yuma Proving Ground during May through August 1968.

The Approved Technical Characteristics of the test item were used as criteria to determine test item reliability.

The requirements that the system be capable of statically supporting twice the rated load without evidence of permanent deformation and that the system demonstrate sufficient reliability and durability to lift 150 percent of its rated load to a height of 60 inches for 50 cycles were deleted from the test (Ref 5, App VI).

Testing to determine if test item met criteria listed in Paragraph 2.3.1.1c was not conducted due to satisfactory completion of the test during the USAAESWBD service test conducted in June 1967.

2.2 TEST NO. 1 - PHYSICAL CHARACTERISTICS

2.2.1 Objective

To determine the physical characteristics of the test item.

2.2.1.1 Test Criteria.

a. Individual components of the system shall be sufficiently lightweight to enable carrying for short distances and loading by four men onto a military vehicle (Para. 1, App II).

b. No component or group of components of the system shall be of such a size as to prevent air transport by cargo aircraft in accordance with applicable portions of Appendices A and B of AR 705-35. Component parts of the system must comply with the requirements of approved specifications (federal, military, and/or industry), and be made corrosion resistant through use of applicable methods and materials (Para. 3, App II).

2.2.2 Method

The test item components were examined, measured, weighed, carried 25 yards by four men and loaded onto a military vehicle. Technical characteristics were reviewed and checked against AR 705-35. A weight comparison was made between a test item having a hydraulic system and a test item having a manual chain hoist.

2.2.3 Results

a. Weights of the test item and its components are contained in Table 1, Appendix I.

b. No components or group of components of the test item exceeded 15 feet in length, 70 inches in width, and 60 inches in height.

c. Individual components of the system (as listed in Table 1, App I), with the exception of the power pack assembly with hydraulic oil, were carried 25 yards by four men, and loaded onto an M35A1, 2-1/2 ton truck. The power pack assembly could be carried with extreme effort but could not be loaded onto the M35A1 truck.

d. The chains on the manual chain hoist rusted while exposed to the desert environment.

2.2.4 Analysis

All components of the test item are within the size limitations for air transport by cargo aircraft.

The power pack assembly with hydraulic oil cannot be carried and loaded onto a military vehicle by four men without complete disregard for the safety and physical well being of the men involved. However, if the hydraulic oil were drained from the power pack the weight would be reduced by approximately 65 pounds; at this reduced weight the test item can be carried by four men.

After exposure to the climatic conditions of the test site for 3 weeks, rust began to appear on the manual chain hoist chains. This occurred under no rain, low humidity conditions.

2.3 TEST NO. 2 - OPERATIONAL TEST

2.3.1 Objective

To determine the operational suitability of the test item.

2.3.1.1 Test Criteria.

a. The system must be capable of manual assembly, from shipping to operational condition, without special tools or materials handling equipment. Assembly time for a device (17,500-pound capacity) from removal from shipping skids to erection must be less than 1 hour, when using four men.

b. The device must have a lifting capacity of 17,500 pounds and when used in pairs as a system must be capable of lifting a load measuring 108 inches high, 110 inches wide, and 336 inches long, weighing 35,000 pounds, to a height which will provide a 60-inch ground clearance and will permit placement onto a ground transport vehicle up to 120 inches in width.

c. The system must have mechanical leveling provisions to insure stability in all directions for all loads up to rated load on sloping terrain up to and including 5-degree slopes.

d. The device, when assembled, must be capable of being man-propelled short distances over unsurfaced and non-trafficked areas in the vicinity of forward airfields.

e. The system must be capable of raising the rated load to a 60-inch height in approximately 120 seconds, using self-contained gasoline engine operated power packages, together with hydraulic control and lift components.

f. The device shall be operable from a single control station.

g. The system must be capable of manual operation if power is not available. With manual operation, the lift rate requirement listed for mechanical operation is not mandatory.

h. The system must meet the requirements of the current revision of Specification MIL-T-11748 (Signal Corps), "Interference Reduction for Electrical and Electronic Equipment."

2.3.2 Method

a. Time required for manual assembly of the test item from shipping to operational conditions was recorded. Four men, one NCO who was given on-the-job training for approximately 4 hours, and three enlisted men who were given a 15-minute briefing on the erection of the gantry device, assembled the test item.

b. The test items were used for a period of 3 months to lift various loads within the stated weight and dimensional limitations. Lift and lowering times were recorded.

c. The test item was man-moved for short distances when assembled and disassembled. It was man-moved when assembled as both a manual and a mechanical device. The areas in which these tests were conducted were composed of rock alluvium, the dominant features of gravelly deserts, the most common desert type, made up of gravel stratum mixed with sands and silts.

d. The test item was tested manually and mechanically and the results were recorded.

e. Manpower necessary to operate control stations was observed.

f. A radio interference test was conducted on the test item and the results recorded. Specifications MIL-STD-461 and 462 were used in place of MIL-T-11748 as it was not available during testing.

g. Still pictures were taken and analyzed.

h. Engineering data were recorded as necessary.

i. A test load weighing 35,000 pounds was modified to simulate a load measuring 110 inches wide and 336 inches long. Height measurements were taken to determine height limitations. A ground transport vehicle (aircraft loader) measuring 120 inches in width was then driven between the gantries to permit load placement.

2.3.3 Results

a. The gantry device was manually assembled from shipping to operational condition, without special tools or materials handling equipment, in 58 minutes.

b. Operational data are contained in Table 2, Appendix I.

c. The test item was man-moved a distance of 300 feet when assembled for manual operation and when assembled for mechanical operation.

d. The test item was manually operated with loads up to 17,500 pounds using one device. A 35,000-pound system could not be tested due to the nonavailability of enough chain hoist during testing. Operational data are contained in Table 3, Appendix I.

e. One control station is required when operating a gantry device. Two control stations are required when operating a gantry system.

f. The test item met the "Interference Production for Electrical and Electronic Equipment" requirements. Data are contained in Table 4, Appendix I.

g. A ground transport vehicle up to 120 inches wide can be driven between a gantry system and pick up a load which is 110 inches wide, 336 inches long, and 108 inches high (Fig. 1, App V).

2.3.4 Analysis

Criteria were met with the following exceptions:

a. During erection of the test item, a wrench lever would not lock and had to be held in position so that the baseplate could be lowered.

b. Although the test item was assembled from shipping to operational condition by four men in less than 1 hour, it must be noted that the cart assembly was received with the cylinders and hydraulic hose connected. Had the cylinders been shipped as separate units in the shipping containers constructed by the U.S. Army Natick Laboratories, the time

requirement would not have been met. Also, both ends, as well as the top of the shipping container must be removed if no materials handling equipment is utilized. (Future shipping procedures should be determined.) Since the test item was shipped from Natick, Massachusetts, to Yuma, Arizona, with the cylinders mounted and no damage was incurred, it is our opinion that special cylinder crates are unnecessary. It was also noted that the shipping skids used were nailed down in a kite box shaped crate. If the shipping skids were constructed in the shape of a solid rectangular box with a fold back lid, the time required to remove the test item from the shipping skids would be considerably less (Ref 3.5, App III).

c. The gantry was moved a distance of 300 feet in 1 minute and 50 seconds without difficulty when assembled for manual operation. When assembled for mechanical operation the gantry became stuck in the sand on two occasions (movement time 2 minutes and 20 seconds) and although movement was continued with added effort, extreme caution had to be taken to prevent the gantry from toppling. It is also noted that since there are numerous types of soil groups in forward airfield areas, only one of which was available at this testing area, satisfaction of the requirement cannot be determined.

d. Although the test item may be manually operated with loads up to 35,000 pounds, the physical stress on a man's hands creates numerous blisters and open wounds (Fig. 2, App V). Therefore, gloves to eliminate this situation should be standard issue with test item.

2.4 TEST NO. 3 - MAINTENANCE AND RELIABILITY

2.4.1 Objective

To determine if the test item meets maintenance and reliability requirements as defined by the Operational and Technical Characteristics.

2.4.1.1 Test Criteria:

a. The system, when operated by its hydraulic power package, shall demonstrate with 95 percent reliability the capability of performing a daily mission. A daily mission is defined as a total of 50 cycles (lifts of various load weights within the rated capacity. This implies 20 mission days as Mean Time Between Failures (MTBF). A failure is defined as that which prevents the unit from completing its assigned mission and cannot be repaired by the operator with the tools and materials provided within 30 minutes. Unscheduled organizational maintenance should not exceed 30 minutes during the performance of a daily mission. The total maintenance manhours will not exceed 10 percent of the operating hours on the basis of 8 hours of operation equal to 1 mission day. Total maintenance will include scheduled and unscheduled maintenance from operator level through direct support level.

b. The system must be easily maintained under field conditions. Components must be interchangeable between like items of the system. Maintenance costs must be a minimum for systems of this type.

c. The system must be capable of operation and storage in temperatures from -65°F to +125°F.

2.4.2 Method

a. An updated Draft Technical Manual, Manufacturers' Maintenance and Operating Manual, and TM 5-2805-203-14 were the only guides available in performing all maintenance during the conduct of this test.

b. A preoperational inspection was performed in accordance with pretesting procedures. However, preoperational inspection time was not recorded as it is not considered a portion of maintenance time. Technical inspections were conducted by maintenance personnel as required. Daily inspections and preventive maintenance operations were performed as directed in Draft Technical Manual and TM 5-2805-203-14.

c. Unscheduled and scheduled maintenance was performed as required. Records were maintained for all maintenance operations to include time required and reasons for actions performed.

d. Soil and ambient air temperatures and relative humidity were recorded during the operation of the test item.

e. Four individual test items were used as a device (two gantries used in unison) and as a system (four gantries used in unison). Each individual gantry was operated a total of 50 cycles per day for 20 working days.

2.4.3 Results

a. The test items, four each, which were used as two devices and as one system during testing, were operated for a total of 91.2 engine hours. During these operations, 1.7 manhours of scheduled and unscheduled maintenance were performed. The scheduled maintenance consisted of 0.5 manhours for the 25-hour organizational maintenance of the gasoline engine.

For details of scheduled and unscheduled maintenance, see Table 1, Appendix IV. In addition, operator daily inspection and servicing were performed requiring approximately 5 minutes per day.

Daily preventive maintenance was performed by test personnel without difficulty.

b. Eleven unscheduled maintenance actions occurred during engineer testing, requiring a total of 1.2 manhours to accomplish (Table 1, App IV).

c. Table 2, Appendix IV, shows gantry operating hours, active maintenance time, maintenance rates, and mean time between failures. The maintenance ratio, based on scheduled and unscheduled maintenance actions but exclusive of operator daily preventive maintenance, and initial inspection was 0.019 for the entire engineering test period.

d. A limited amount of repair parts were furnished with the test item; however, most replacement parts were either locally obtained or fabricated. Parts which could not be obtained in this manner were taken from like items of the system. Components are interchangeable.

e. Some of the unscheduled maintenance was of a serious nature and required a high degree of maintenance skill. However, the test NCO, who carries an MOS of 62E40 (Heavy Equipment Supervisor), and other test personnel were able to correct all unscheduled maintenance without outside assistance with the exception of oil leaks which came from the cylinder seals and could not be corrected.

f. Soil temperatures ranged from 73°F to 109°F. Ambient air temperature ranged from 68°F to 107°F. Relative humidity ranged from 17 to 64 percent. For daily meteorological readings refer to Table 2, Appendix I.

2.4.4 Analysis

a. The amount of maintenance required and the number of parts consumed during engineering testing were within stated criteria.

b. The system, when operated by its hydraulic power package, will perform a daily mission with 95 percent reliability.

c. One failure, Item L, Table 1, Appendix IV occurred due to attempted repair. It has been established that this item should be replaced and repair should not be attempted for safety reasons. Replacement time is 15 minutes.

d. Oil seepage from the cylinder seals (Fig. 3, App V) could not be stopped by tightening. Although oil seepage was very slight, it could cause damage to the parachutes of a rigged load. The seals should be replaced with a higher grade seal to avoid leakage.

e. Since the gantry was tested under desert environmental conditions for over 20 days of operation, it can be assumed that the test item will operate under extreme high temperatures. Although ambient temperatures did not reach 125°F the system is capable of operation under such conditions.

Test item operation at low ambient temperatures could not be determined at this test site.

f. Pressure gage failures (four each) were not considered either a deficiency or shortcoming; however, correction of these failures required 15 minutes of active maintenance time. Of the four failed gages, three were furnished by this installation and had brass movements. One failed gage, which was an initial component of the test item, contained a bronze movement (Para. 3.1, App III, and Fig. 4, App V).

2.5 TEST NO. 4 - HUMAN FACTORS AND SAFETY

2.5.1 Objectives

To determine if the test item conforms to the principles of human factors engineering.

2.5.1.1 Test Criteria. The test item must be safe for its intended use.

2.5.2 Method

The safety criteria as established by the USAAESWBD after service testing in June 1967 was reviewed and followed. Any safety hazards which were not discovered during the service test were recorded.

2.5.3 Results

During the 20-day reliability test of the gantry system, one device had performed the following:

50 lifts of 12,000 pounds each
40 lifts of 12,500 pounds each

Total operating time was 3 hours and 25 minutes. After 67 lifts a small oil leak was noticed which was coming from Items A and B of Figure 3.

The leak was very small at the time (3 or 4 drops of oil per lift). Testing was continued and the leakage kept under observation. At the completion of 90 lifts the leak had increased (10 to 12 drops of oil per lift) and operation was ceased. An attempt was made to tighten the left bolt (Item A). When this was done the separation around the flange (Item B) increased due to the tautness of the manifold line (Item C, Fig. 3).

The entire assembly (Items A through D, Fig. 3) was then removed. Teflon tape was placed around Item A, Figure 3, and a flaring kit was used to flare the flange out on Item B, Figure 3. The assembly was then reinstalled. The motor was started and the load lifted to approximately 36 inches off the ground. The position valves were then pushed down so that the load would begin to descend.

At this time the flange "blew out" of its fitting, spraying oil approximately 30 feet in both directions, and the load suspended by the gantry dropped to the ground.

Further investigation disclosed that the clamp connections (Items E and F, Fig. 4) failed to restrain the manifold hose in its proper location. The hydraulic "hammer action" over the period of 3-1/2 hours of operation and 90 lifts pulled the manifold hose in a direction away from the fitting and through the clamps approximately 1 inch. This,

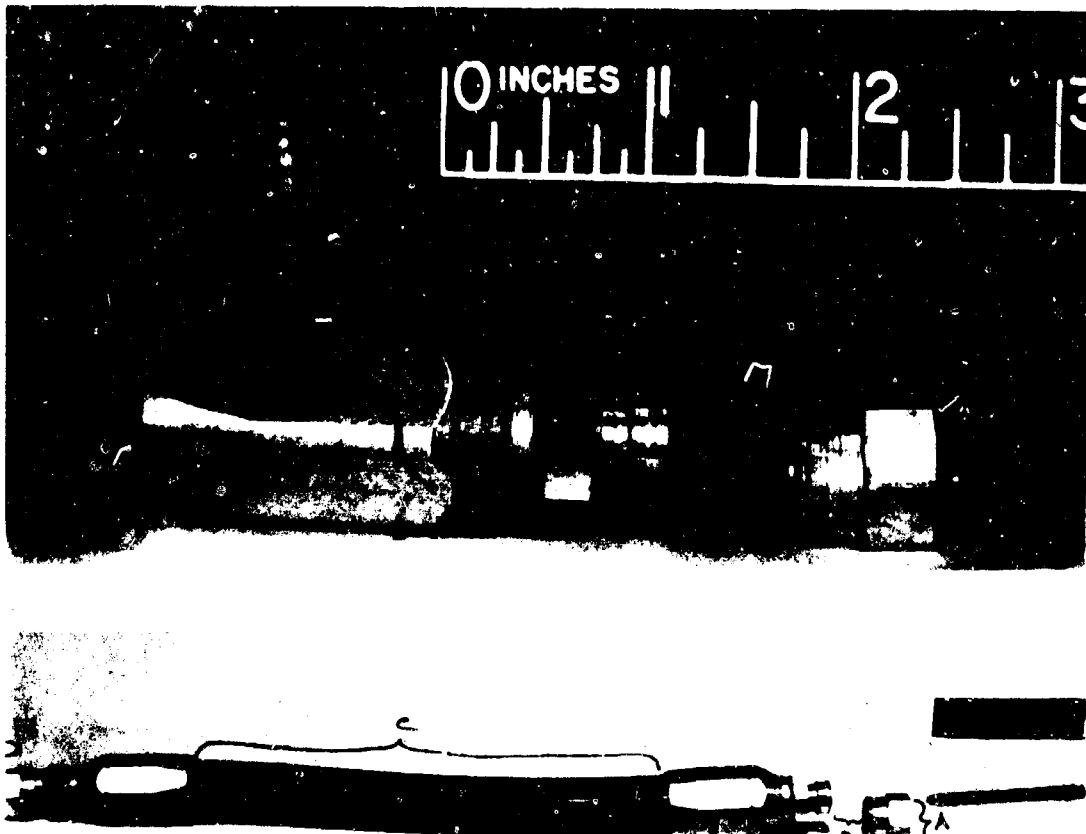


FIGURE 3. Hydraulic hose and fittings.

in turn, pulled the hose so taut that all force was being exerted on the final connection (Items A and B, Fig. 3). The continuing "hammer action" could have been the reason the fittings loosened and the leakage started. Hydraulic oil temperature at this point is 165°F with a maximum oil pressure of 2300 psi.

b. When the angle from the accessory beam center fitting to the load connection point exceeds 3.6 degrees it is possible for the cable to jump out of the sheave when lifting the load. The load will drop approximately 8 inches when this occurs (Fig. 5, App V).

c. Safety hazards (Para. 3.2 and 3.3, App III) should be corrected (Fig. 2 and 6, App V).

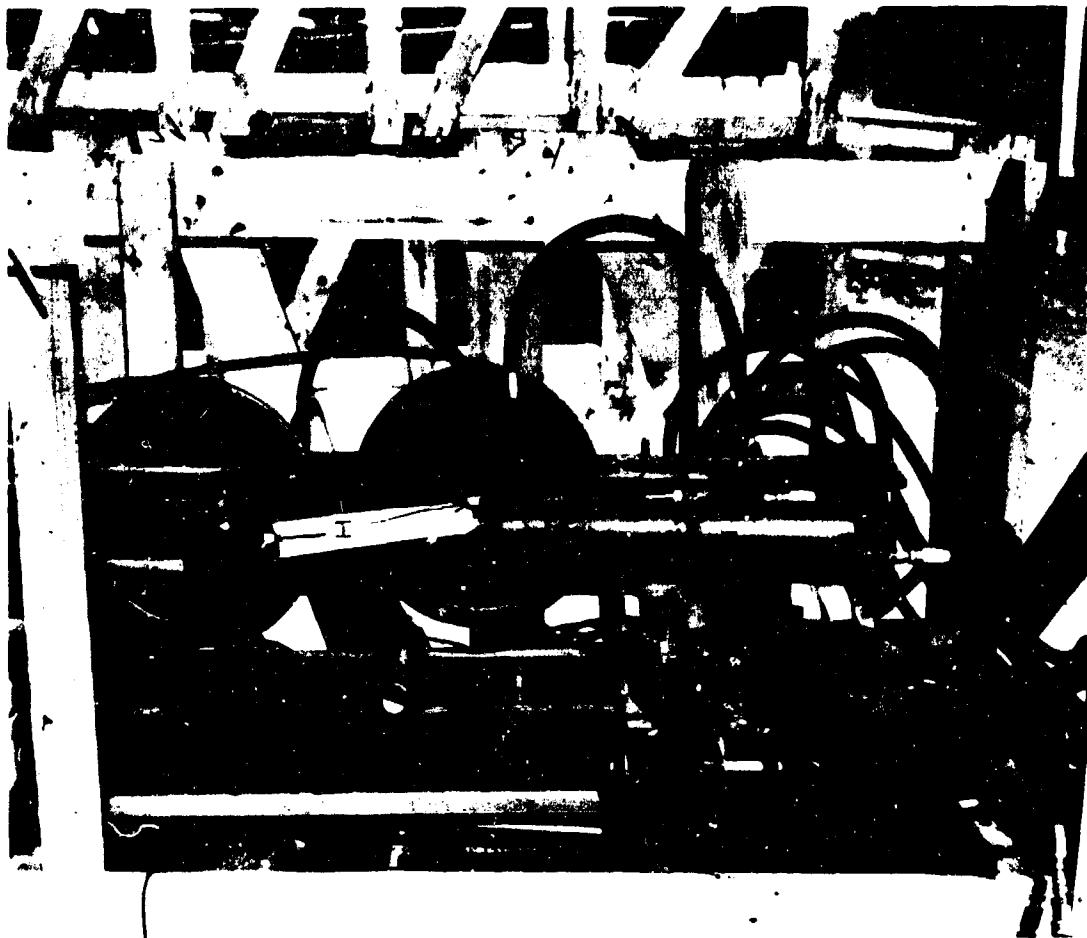


FIGURE 4. Cart assembly.

2.5.4 Analysis

a. The clamp connections, Items E and F (Fig. 4) should be checked daily to insure that they secure and that the manifold hose is restrained in its proper location.

b. The load will fall if the referenced hose assembly or fittings fail. These items are located between the flow control valve and cylinder, and should be checked daily for oil leaks. No attempt should be made to repair referenced hose or to flare the flanged portions of the swivel nuts. Operation should be ceased and the faulty items replaced.

c. Caution should be used during rigging to avoid connecting the gantry to the load at more than a 3.6-degree angle as this can damage the gantry cable and presents a possible safety hazard.

NOTE: Figure 4 is not a photograph of the gantry on which the incident occurred and is for reference only. Clamp E is normally located at Point G and Clamp F at Point H. Point I is the normal location for the hose shown in Figure 1.

APPENDIX I. TEST DATA

TABLE 1. Gantry Components

<u>Nomenclature of Component</u>	<u>Unit of Issue</u>	<u>Unit Wt (lb)</u>	<u>Number of Units</u>	
			<u>Per Device (2 gantries)</u>	<u>Per System (4 gantries)</u>
Left hand column assembly with winch	Ea	190	4	8
Right hand column assembly with stay bar	Ea	170	4	8
Main beam assembly with hinge pins and rods	Ea	290	2	4
Cart assembly with cylinders and hydraulic hose	Ea	365	2	4
Accessory beam	Ea	100	2	4
Power pack assembly with hydraulic oil	Ea	421	1	2
Manual chain hoist	Ea	93.5	4	8
Tie-down chain assembly	Ea	10.5	4	8
5-gallon jerry can with gas and gas line	Ea	53.5	1	2

Total weight of gantry device (2 each gantries) for manual operation only: 2636.0 pounds.

Total weight of gantry device (2 each gantries) for mechanical operation only: 3478.5 pounds.

Total weight of gantry device (2 each gantries) for manual and mechanical operation: 3840.5 pounds.

TABLE 2. Electrical Operation Data

Country Bed 1 and 2
Load Weight: 8060 lb
Maximum Height Load Lifted: 62 in.
Power Pack Bed 1
Ambient Temperature (°F):
High, 78; Low, 78

Country Bo. 3 and 4
Load weight: 12,000 lb
Maximum Weight Load lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 75, Low, 70

Country No. 1 and 2
Load Weight: 7500 lb
Maximum Weight Load Lifted: 62 lbs.
Power Pack No. 1
Ambient Temperature (°F):
High, 78; Low, 76
Humidity (%): High, 55; Low, 55

Cycle No.	Pressure Variation			Cycle No.	Pressure Variation			Cycle No.	Pressure Variation						
	Time (sec)	Up	Down		Time (sec)	Up	Down		Time (sec)	Up	Idle				
1	41	49	1300	1100	2100	1	49	1200	1300	2000	1	45	1300	1300	1600
2	42	48	1300	1100	2100	2	49	52	52	52	2	43	1200	1100	1200
3	43	47	1300	1100	2100	3	52	52	52	52	3	42	1200	1200	1200
4	45	45	1300	1100	2100	4	52	52	52	52	4	42	1200	1200	1200
5	46	46	1300	1100	2100	5	52	52	52	52	5	42	1200	1200	1200
6	47	47	1300	1100	2100	6	52	52	52	52	6	42	1200	1200	1200
7	48	48	1300	1100	2100	7	52	52	52	52	7	42	1200	1200	1200
8	49	49	1300	1100	2100	8	52	52	52	52	8	42	1200	1200	1200
9	50	50	1300	1100	2100	9	52	52	52	52	9	42	1200	1200	1200
10	51	51	1300	1100	2100	10	52	52	52	52	10	42	1200	1200	1200
11	52	52	1300	1100	2100	11	52	52	52	52	11	42	1200	1200	1200
12	53	53	1300	1100	2100	12	52	52	52	52	12	42	1200	1200	1200
13	54	54	1300	1100	2100	13	52	52	52	52	13	42	1200	1200	1200
14	55	55	1300	1100	2100	14	52	52	52	52	14	42	1200	1200	1200
15	56	56	1300	1100	2100	15	52	52	52	52	15	42	1200	1200	1200
16	57	57	1300	1100	2100	16	52	52	52	52	16	42	1200	1200	1200
17	58	58	1300	1100	2100	17	52	52	52	52	17	42	1200	1200	1200
18	59	59	1300	1100	2100	18	52	52	52	52	18	42	1200	1200	1200
19	60	60	1300	1100	2100	19	52	52	52	52	19	42	1200	1200	1200
20	61	61	1300	1100	2100	20	52	52	52	52	20	42	1200	1200	1200
21	62	62	1300	1100	2100	21	52	52	52	52	21	42	1200	1200	1200
22	63	63	1300	1100	2100	22	52	52	52	52	22	42	1200	1200	1200
23	64	64	1300	1100	2100	23	52	52	52	52	23	42	1200	1200	1200
24	65	65	1300	1100	2100	24	52	52	52	52	24	42	1200	1200	1200
25	66	66	1300	1100	2100	25	52	52	52	52	25	42	1200	1200	1200
26	67	67	1300	1100	2100	26	52	52	52	52	26	42	1200	1200	1200
27	68	68	1300	1100	2100	27	52	52	52	52	27	42	1200	1200	1200
28	69	69	1300	1100	2100	28	52	52	52	52	28	42	1200	1200	1200
29	70	70	1300	1100	2100	29	52	52	52	52	29	42	1200	1200	1200
30	71	71	1300	1100	2100	30	52	52	52	52	30	42	1200	1200	1200
31	72	72	1300	1100	2100	31	52	52	52	52	31	42	1200	1200	1200
32	73	73	1300	1100	2100	32	52	52	52	52	32	42	1200	1200	1200
33	74	74	1300	1100	2100	33	52	52	52	52	33	42	1200	1200	1200
34	75	75	1300	1100	2100	34	52	52	52	52	34	42	1200	1200	1200
35	76	76	1300	1100	2100	35	52	52	52	52	35	42	1200	1200	1200
36	77	77	1300	1100	2100	36	52	52	52	52	36	42	1200	1200	1200
37	78	78	1300	1100	2100	37	52	52	52	52	37	42	1200	1200	1200
38	79	79	1300	1100	2100	38	52	52	52	52	38	42	1200	1200	1200
39	80	80	1300	1100	2100	39	52	52	52	52	39	42	1200	1200	1200
40	81	81	1300	1100	2100	40	52	52	52	52	40	42	1200	1200	1200
41	82	82	1300	1100	2100	41	52	52	52	52	41	42	1200	1200	1200
42	83	83	1300	1100	2100	42	52	52	52	52	42	42	1200	1200	1200
43	84	84	1300	1100	2100	43	52	52	52	52	43	42	1200	1200	1200
44	85	85	1300	1100	2100	44	52	52	52	52	44	42	1200	1200	1200
45	86	86	1300	1100	2100	45	52	52	52	52	45	42	1200	1200	1200
46	87	87	1300	1100	2100	46	52	52	52	52	46	42	1200	1200	1200
47	88	88	1300	1100	2100	47	52	52	52	52	47	42	1200	1200	1200
48	89	89	1300	1100	2100	48	52	52	52	52	48	42	1200	1200	1200
49	90	90	1300	1100	2100	49	52	52	52	52	49	42	1200	1200	1200
50	91	91	1300	1100	2100	50	52	52	52	52	50	42	1200	1200	1200
51	92	92	1300	1100	2100	51	52	52	52	52	51	42	1200	1200	1200
52	93	93	1300	1100	2100	52	52	52	52	52	52	42	1200	1200	1200
53	94	94	1300	1100	2100	53	52	52	52	52	53	42	1200	1200	1200
54	95	95	1300	1100	2100	54	52	52	52	52	54	42	1200	1200	1200
55	96	96	1300	1100	2100	55	52	52	52	52	55	42	1200	1200	1200
56	97	97	1300	1100	2100	56	52	52	52	52	56	42	1200	1200	1200
57	98	98	1300	1100	2100	57	52	52	52	52	57	42	1200	1200	1200
58	99	99	1300	1100	2100	58	52	52	52	52	58	42	1200	1200	1200
59	100	100	1300	1100	2100	59	52	52	52	52	59	42	1200	1200	1200
60	101	101	1300	1100	2100	60	52	52	52	52	60	42	1200	1200	1200
61	102	102	1300	1100	2100	61	52	52	52	52	61	42	1200	1200	1200
62	103	103	1300	1100	2100	62	52	52	52	52	62	42	1200	1200	1200
63	104	104	1300	1100	2100	63	52	52	52	52	63	42	1200	1200	1200
64	105	105	1300	1100	2100	64	52	52	52	52	64	42	1200	1200	1200
65	106	106	1300	1100	2100	65	52	52	52	52	65	42	1200	1200	1200
66	107	107	1300	1100	2100	66	52	52	52	52	66	42	1200	1200	1200
67	108	108	1300	1100	2100	67	52	52	52	52	67	42	1200	1200	1200
68	109	109	1300	1100	2100	68	52	52	52	52	68	42	1200	1200	1200
69	110	110	1300	1100	2100	69	52	52	52	52	69	42	1200	1200	1200
70	111	111	1300	1100	2100	70	52	52	52	52	70	42	1200	1200	1200
71	112	112	1300	1100	2100	71	52	52	52	52	71	42	1200	1200	1200
72	113	113	1300	1100	2100	72	52	52	52	52	72	42	1200	1200	1200
73	114	114	1300	1100	2100	73	52	52	52	52	73	42	1200	1200	1200
74	115	115	1300	1100	2100	74	52	52	52	52	74	42	1200	1200	1200
75	116	116	1300	1100	2100	75	52	52	52	52	75	42	1200	1200	1200
76	117	117	1300	1100	2100	76	52	52	52	52	76	42	1200	1200	1200
77	118	118	1300	1100	2100	77	52	52	52	52	77	42	1200	1200	1200
78	119	119	1300	1100	2100	78	52	52	52	52	78	42	1200	1200	1200
79	120	120	1300	1100	2100	79	52	52	52	52	79	42	1200	1200	1200
80	121	121	1300	1100	2100	80	52	52	52	52	80	42	1200	1200	1200
81	122	122	1300	1100	2100	81	52	52	52	52	81	42	1200	1200	1200
82	123	123	1300	1100	2100	82	52	52	52	52	82	42	1200	1200	1200
83	124	124	1300	1100	2100	83	52	52	52	52	83	42	1200	1200	1200
84	125	125	1300	1100	2100	84	52	52	52	52	84	42	1200	1200	1200
85	126	126	1300	1100	2100	85	52	52	52	52	85	42	1200	1200	1200
86	127	127	1300	1100	2100	86	52	52	52	52	86	42	1200	1200	1200
87	128	128	1300	1100	2100	87	52	52	52	52	87	42	1200	1200	1200
88	129	129	1300	1100	2100	88	52	52	52	52	88	42	1200	1200	1200
89	130	130	1300	1100	2100	89	52	52	52	52	89	42	1200	1200	1200
90	131	131	1300	1100	2100	90	52	52	52	52	90	42	1200	1200	1200
91	132	132	1300	1100	2100	91	52	52	52	52	91	42	1200	1200	1200
92	133	133	1300	1100	2100	92	52	52	52	52					

Remarks: Cycle No. 42. Hose connectors were disconnected from the power pack assembly and reversed so that the four-way control valve levers would lift and lower in conjunction. Upon replacing the connectors a heavy leak started in connection No. 3. No visual damage to the interior positions of the connectors was noted and leakage was stopped by trial and error adjustment of the hose fitting (EPA 15-2).

Remarks: After 5 minutes of test life operation one of the manifold base connectors which was connected to the power pack began to leak. The fitting was tightened and held for around 5 minutes. The fitting began leaking again and although tightened to its capacity the oil leakage increased and developed into a heavy spray. Operation was ceased and the connector was disconnected for repair. The connector had not been filled with "white lead" during production and was repaired by placing teflon tape between the fittings [EPR 15-4]. Cycle No. 19. Manifold base "jumped" out of the manifold base support [EPR 15-5].

Remarks: No problems were incurred.

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 3 and 4
Load Weight: 12,500 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 78; Low, 72
Humidity (%): High, 55; Low, 55

Gantry No. 1 and 2
Load Weight: 7060 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1
Ambient Temperature (°F):
High, 78; Low, 72
Humidity (%): High, 21; Low, 18
Soil Temperature (°F): High, 82; Low, 75

Gantry No. 3 and 4
Load Weight: 13,000 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 78; Low, 72
Humidity (%): High, 21; Low, 18
Soil Temperature (°F): High, 75; Low, 72

Cycle No.	Pressure Variation			Cycle No.	Pressure Variation			Cycle No.	Pressure Variation				
	Up	Time (sec)	Down		Up	Time (sec)	Down		Up	Time (sec)	Idle		
1	50	49	1200	1000	2000			1	53	47	1200	0900	2100
2	49	48						2	51	48			
3	49	49						3	51	49			
4	48	46						4	49	48			
5	49	49						5	50	49	1100		
6	49	49						6	50	49			
7	49	49	1100					7	51	49			
8	47	50						8	50	49			
9	47	50						9	50	50			
10	49	50						10	48	50			
11	47	49						11	49	50			
12	48	52						12	48	50			
13	47	52	1800					13	49	51			
14	48	51						14	49	50			
15	47	50	900					15	48	50			
16	47	50						16	49	50			
17	47	50						17	49	51			
18	47	51						18	49	51			
19	47	51						19	48	51	2000		
20	47	50						20	48	51			
21	49	50						21	48	51			
22	49	50						22	48	51			
23	48	51						23	48	51			
24	48	51						24	49	51			
25	47	52						25	48	51			
26	47	50						26	Not Recorded				
27	48	50						27					
28	50	52						28					
29	47	50						29					
30	47	52						30					
31	Not Recorded							31					
32								32					
33								33					
34								34					
35								35					
36								36					
37								37					
38								38					
39								39					
40	Not Recorded							40	Not Recorded				
41	48	50						41	48	51			
42	47	50						42	48	51			
43	47	51						43	48	51			
44	47	51						44	49	52			
45	47	49						45	50	52			
46	47	50						46	50	52			
47	48	50						47	50	52	2000		
48	47	51						48	50	51			
49	46	50						49	48	52			
50	49	51						50	47	52			

Remarks: Manifold hose "jumped" out of the manifold hose support approximately 50 percent of the cycles when the load was starting to be lowered from its suspended position (EPR LS-5-2). Cycle No. 17. Oil leak at connection of cylinder and hydraulic hose (EPR LS-6).

Remarks: No problems were incurred.

Remarks: No problems were incurred.

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 1 and 2
Load Weight: 6560 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1
Ambient Temperature (°F):
High, 79; Low, 74
Humidity (%): High, 21; Low, 17
Soil Temperature (°F): High, 61; Low, 77

Gantry No. 3 and 4
Load Weight: 13,500 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 79; Low, 74
Humidity (%): High, 21; Low, 17
Soil Temperature (°F): High, 61; Low, 77

Gantry No. 1 and 2
Load Weight: 6060 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1
Ambient Temperature (°F):
High, 74; Low, 68
Humidity (%): High, 40; Low, 20
Soil Temperature (°F): High, 62; Low, 73

Cycle No.	Pressure Variation				Cycle No.	Pressure Variation				Cycle No.	Pressure Variation						
	Up	Down	Up	Down		Up	Down	Up	Down		Up	Down	Up	Down			
1	41	46	1200	1100	1700	1	49	47	1300	0900	1900	1	41	48	1100	1000	1700
2	41	46				2	50	46				2	40	49			
3	41	47				3	50	49				3	40	48			
4	41	47	1000			4	50	47	1200			4	40	49			
5	41	48				5	50	48				5	39	48			
6	41	48				6	50	48		2000		6	40	48			
7	41	48				7	50	48				7	39	48			
8	41	49				8	50	49				8	39	49	1000		
9	40	50			1800	9	49	50				9	39	48			
10	Not Recorded				10	49	50				10	39	48			1800	
11					11	Not Recorded					11	39	48				
12					12						12	39	48				
13					13						13	38	48				
14					14						14	38	48				
15					15						15	39	48			1100	
16					16						16	39	48				
17					17						17	39	48				
18					18						18	39	49				
19					19						19	39	49				
20					20						20	38	48				
21					21						21	37	50				
22					22						22	39	50				
23					23						23	39	50				
24					24						24	40	49				
25	Not Recorded				25	Not Recorded					25	38	51				
26	39	51			26	49	50				26	37	49				
27	40	50			27	50	50				27	39	50				
28	40	52			28	49	50				28	39	51				
29	41	49			29	49	48				29	38	50				
30	40	49			30	49	49				30	39	50			1700	
31	40	49			31	49	50				31	37	51				
32	40	50			32	49	50				32	40	50				
33	39	50			33	49	49				33	37	51				
34	40	49			34	49	50				34	38	51				
35	40	50			35	48	51				35	38	52				
36	41	51			36	49	50				36	37	50				
37	40	50			37	50	51				37	38	52				
38	41	51			38	49	50				38	38	51				
39	40	50			39	Not Recorded					39	38	52				
40	Not Recorded				40						40	37	50			1800	
41					41						41	38	51				
42					42						42	37	52				
43					43						43	38	51				
44					44						44	38	52				
45					45						45	37	51				
46					46						46	37	52				
47					47						47	38	50				
48					48						48	38	50				
49					49						49	38	51				
50	Not Recorded				50	Not Recorded					50	38	50				

Remarks: No problems were incurred.

Remarks: No problems were incurred.

Remarks: No problems were incurred.

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 3 and 4
 Load Weight: 14,000 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 2
 Ambient Temperature (°F):
 High, 84; Low, 68
 Humidity (%): High, 40; Low, 20
 Soil Temperature (°F): High, 82; Low, 73

Gantry No. 1 and 2
 Load Weight: 5560 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1
 Ambient Temperature (°F):
 High, 96; Low, 93
 Humidity (%): High, 24; Low, 20
 Soil Temperature (°F): High, 94; Low, 94

Gantry No. 3 and 4
 Load Weight: 14,500 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 2
 Ambient Temperature (°F):
 High, 96; Low, 93
 Humidity (%): High, 24; Low, 20
 Soil Temperature (°F): High, 94; Low, 94

Cycle No.	Pressure Variation			Cycle No.	Pressure Variation			Cycle No.	Pressure Variation		
	Time (sec) Up	Time (sec) Down	Time (sec) Idle		Time (sec) Up	Time (sec) Down	Time (sec) Idle		Time (sec) Up	Time (sec) Down	Time (sec) Idle
1	51	50	1200 1000 1900	1	36	49	1100 1100 1700	1	53	49	1200 1000 1800
2	50	50		2	37	50		2	53	50	
3	51	50		3	36	49		3	51	49	
4	50	49		4	36	49		4	52	49	
5	50	51		5	37	50		5	51	50	
6	52	49		6	37	50		6	52	50	
7	52			7	36	52		7	51	52	
8	52	51		8	36	51		8	52	51	
9	50	52		9	36	51		9	52	51	
10	50	50		10	36	51		10	52	51	
11	51	51	2100	11	35	50		11	52	50	
12	51	50		12	36	50		12	52	50	
13	52	51		13	36	51		13	52	51	
14	53	51		14	35	49		14	52	49	
15	51	52		15	36	49		15	52	49	
16	50	50		16	36	50		16	51	50	
17	52	52		17	37	49		17	51	49	
18	52	51		18	36	50		18	50	50	
19	51	52		19	36	50		19	51	50	
20	51	50		20	37			20	52	50	
21	52	51		21	37	50		21	52	50	
22	51	52		22	36	49		22	52	49	
23	51	51		23	37	49		23	51	49	
24	50	52		24	37	49		24	52	49	
25	51	51		25	36	49		25	52	49	
26	52	52		26	36	50		26	51	50	
27	51	50		27	36	50		27	52	50	
28	52	51		28	36	50		28	51	50	
29	51	50		29	36	50		29	52	50	
30	50	53	1900	30	37	50	1000	30	51	50	1400 1100
31	51	48		31	37	50		31	51	50	
32	50	49		32	37	50		32	52	50	
33	49	48		33	37	50		33	51	50	
34	50	49		34	37	50		34	52	50	
35	50	48		35	37	50		35	52	50	
36	50	48		36	36	50		36	51	50	
37	50	48		37	36	50		37	52	50	
38	51	49		38	36	50		38	51	50	
39	50	48		39	36	50		39	51	50	
40	50	48		40	36	50		40	52	50	
41	50	48		41	36	50		41	52	50	
42	50	48		42	36	50		42	52	50	
43	50	48		43	36	50		43	52	50	
44	50	48		44	36	50		44	52	50	
45	50	48		45	36	50		45	52	50	
46	50	48		46	36	50		46	51	50	
47	50	48		47	36	50		47	52	50	
48	51	49		48	36	50		48	52	50	
49	50	49		49	36	50		49	52	50	
50	50	48		50	36	50		50	51	50	

Remarks: No problems were incurred.

Remarks: No problems were incurred.

Remarks: Cycle No. 13. Pressure gage broke. Item was replaced (Ref App III) (EPR L5-7).

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 1 and 2
Load Weight: 5060 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1

Gantry No. 3 and 4
Load Weight: 15,000 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2

Gantry No. 1 and 2
Load Weight: 4560 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1

Cycle No.	Pressure Variation			Up	Down	Idle
	Time (sec)	Up	Down			
1	38	50	1000	1100	1700	
2	37	49				
3	37	49				
4	36	49				
5	36	49				
6	36	49				
7	36	49				
8	36	49				
9	36	50				
10	35	49				
11	36	49				
12	35	50				
13	35	49				
14	35	50				
15	35	49				
16	35	49				
17	35	49				
18	35	49				
19	35	49				
20	35	50				
21	36	50				
22	35	49				
23	35	49				
24	35	50				
25	35	50				
26	35	50				
27	35	49				
28	35	49				
29	35	50				
30	35	50				
31	36	50				
32	36	49				
33	35	49				
34	35	49				
35	35	50				
36	35	50				
37	35	50				
38	36	50				
39	35	50				
40	35	51				
41	35	50				
42	35	49				
43	35	50				
44	35	50				
45	35	50				
46	36	51				
47	35	51				
48	35	50				
49	35	56				
50	35	51				

Remarks: No problems were incurred.

Remarks: No problems were incurred.

Remarks: No problems were incurred.

Cycle No.	Pressure Variation			Up	Down	Idle
	Time (sec)	Up	Down			
1	36	49	1000	1200	1700	
2	35	49				
3	35	49				
4	35	49				
5	35	49				
6	35	49				
7	35	49				
8	35	49				
9	35	49				
10	35	49				
11	35	49				
12	35	49				
13	35	49				
14	35	49				
15	35	49				
16	35	49				
17	35	49				
18	35	50				
19	35	50				
20	35	50				
21	35	50				
22	35	49				
23	35	50				
24	35	49				
25	35	49				
26	35	49				
27	35	49				
28	35	49				
29	35	50				
30	35	50				
31	35	49				
32	35	50				
33	35	50				
34	35	50				
35	35	50				
36	35	50				
37	35	50				
38	36	50				
39	35	50				
40	35	51				
41	35	50				
42	35	49				
43	35	50				
44	35	50				
45	35	50				
46	36	51				
47	35	51				
48	35	50				
49	35	51				
50	34	51				

TABLE 2. Mechanical Operations Data (Continued)

Gantry No. 3 and 4
Load Weight: 15,500 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2

Gantry No. 1 and 2
Load Weight: 4660 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1
Ambient Temperature (°F):
High, 93; Low, 51.7
Humidity (%): High, 47; Low, 18
Soil Temperature (°F): High, 91; Low, 79

Gantry No. 3 and 4
Load Weight: 16,000 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 93; Low, 51.7
Humidity (%): High, 47; Low, 18
Soil Temperature (°F): High 91; Low, 79

Cycle No.	Pressure Variation			Pressure Variation			Pressure Variation			Pressure Variation		
	Time (sec)	Up	Down	Up	Down	Idle	Up	Down	Idle	Up	Down	Idle
1	52	49	Incorrect readings	1	36	49	1200	1100	1700	1	51	49
2	51	49		2	35	49				2	51	49
3	51	49		3	35	48				3	52	48
4	52	49		4	34	49				4	51	49
5	51	49		5	34	49				5	51	49
6	52	49		6	34	49				6	51	49
7	52	49		7	34	49				7	52	49
8	52	49		8	34	49				8	51	49
9	52	49		9	35	49				9	52	49
10	52	49		10	34	49				10	53	49
11	52	49		11	34	50				11	52	50
12	53	49		12	34	50				12	53	50
13	52	49		13	35	50				13	54	50
14	53	49		14	35	50				14	53	50
15	53	49		15	34	50	1000		1600	15	54	50
16	53	49		16	35	49				16	All readings	
17	53	49		17	34	56				17	approximately	
18	53	50		18	34	56				18	the same.	
19	54	50		19	34	50				19		
20	52	50		20	34	50				20		
21	52	50		21	34	50				21		
22	53	49		22	34	50				22		
23	53	50		23	34	50				23		
24	53	49		24	34	50				24		
25	53	49		25	34	50				25		
26	52	49		26	34	50				26		
27	52	49		27						27		
28	53	49		28						28		
29	53	50		29						29		
30	53	49		30						30		
31	53	49		31						31		
32	54	50		32						32		
33	53	50		33						33		
34	54	50		34						34		
35	54	50		35						35		
36	54	50		36						36		
37	54	50		37						37		
38	54	50		38						38		
39	54	50		39						39		
40	54	50		40						40		
41	54	50		41						41		
42	54	50		42						42		
43	54	50		43						43		
44	54	50		44						44		
45	54	50		45						45		
46	54	50		46			0900		1700	46		
47	54	50		47						47		
48	54	51		48						48		
49	54	51		49						49		
50	54	50		50	34	50				50		

Remarks: Pressure gage worn and giving faulty pressure readings. Item was replaced (EPR 15-7-2).

Remarks: No problems incurred.

Remarks: Pressure gage worn and giving faulty readings. Item was replaced.

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 1 and 2
Load Weight: 3560 lb.
Maximum Height Load Lifted: 62 in.
Power Pack No. 1
Ambient Temperature (°F):
High, 100; Low, 98
Humidity (%): High, 36; Low, 28

Gantry No. 3 and 4
Load Weight: 16,500 lb.
Maximum Height Load Lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 100; Low, 98
Humidity (%): High, 36; Low, 28

Gantry No. 1 and 2
Load Weight: 3560 lb.
Maximum Height Load Lifted: 62 in.
Power Pack No. 1
Ambient Temperature (°F):
High, 101; Low, 98
Humidity (%): High, 36; Low, 28

Cycle No.	Time (sec)	Pressure Variation			Time (sec)	Pressure Variation			Time (sec)	Pressure Variation		
		Up	Down	Idle		Up	Down	Idle		Up	Down	Idle
1	34	45	1000	1100	1600	1	54	51	1	33	50	1000
2	35	46				2	54	50	2	33	49	49
3	35	47				3	54	50	3	33	48	48
4	35	48				4	55	50	4	33	50	50
5	36	49				5	55	50	5	33	50	50
6	37	49				6	55	50	6	33	50	50
7	38	49				7	55	50	7	33	50	50
8	39	49				8	55	50	8	33	50	50
9	39	49				9	55	50	9	33	50	50
10	39	49				10	55	51	10	33	46	46
11	39	49				11	54	50	11	34	46	46
12	39	49				12	54	51	12	34	49	49
13	39	49				13	54	51	13	34	49	49
14	39	49				14	55	51	14	34	49	49
15	39	49				15	55	51	15	34	49	49
16	39	49				16	55	51	16	34	49	49
17	39	49				17	55	51	17	34	49	49
18	39	49				18	55	51	18	34	50	50
19	39	49				19	55	51	19	33	50	50
20	39	49				20	55	51	20	33	50	50
21	39	49				21	55	51	21	33	50	50
22	39	49				22	55	51	22	33	50	50
23	39	49				23	55	51	23	33	50	50
24	39	49				24	55	51	24	33	50	50
25	39	49				25	55	51	25	36	50	50
26	39	49				26	55	51	26	36	50	50
27	39	49				27	55	51	27	36	50	50
28	39	49				28	55	51	28	36	50	50
29	39	49				29	55	51	29	36	50	50
30	39	49				30	55	51	30	32	33	33
31	39	49				31	55	51	31	32	34	34
32	39	49				32	55	51	32	32	35	35
33	39	49				33	55	51	33	31	36	36
34	39	49				34	55	51	34	31	37	37
35	39	49				35	55	51	35	31	38	38
36	39	49				36	55	51	36	31	39	39
37	39	49				37	55	51	37	31	40	41
38	39	49				38	55	51	38	31	42	42
39	39	49				39	55	51	39	31	43	43
40	39	49				40	55	51	40	31	44	44
41	39	49				41	55	51	41	31	45	45
42	39	49				42	55	51	42	31	46	46
43	39	49				43	55	51	43	31	47	47
44	39	49				44	55	51	44	31	48	48
45	39	49				45	55	51	45	31	49	49
46	39	49				46	55	51	46	31	50	50
47	39	49				47	55	51	47	31	50	50
48	39	49				48	55	51	48	31	50	50
49	39	49				49	55	51	49	31	50	50
50	39	49				50	55	51	50	31	50	50

Remarks: No problems were incurred.

Remarks: Between Cycle No. 17 and 25. Slight oil leak began on Gantry No. 4. Leak was coming from upper cylinder at fitting connection point. Leak could not be repaired (109 15-8). Pressure gauge were read giving faulty reading. Item was not replaced.

Remarks: No problems were incurred.

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 3 and 4
Load Weight: 17,000 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 107; Low, 96
Humidity (%): High, 38; Low, 18

Gantry No. 1 and 2
Load Weight: 2560 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1
Ambient Temperature (°F):
High, 105; Low, 97
Humidity (%): High, 50; Low, 36
Soil Temperature (°F): High, 103; Low, 95
Gantry 3 and 4
Load Weight: 17,500 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 2
Ambient Temperature (°F):
High, 105; Low, 97
Humidity (%): High, 50; Low, 36
Soil Temperature (°F): High, 103; Low, 95

Cycle No.	Pressure Variation		
	Time (sec)	Up	Down
	Up	Down	Idle
1	54	50	
2	54	48	
3	54	48	
4	54	50	
5	54	50	
6	54	50	
7	54	50	
8	54	50	
9	54	50	
10	54	50	
11	54	48	
12	52	48	
13	53	49	
14	54	49	
15	54	49	
16	54	49	
17	54	49	
18	54	50	
19	54	50	
20	54	50	
21	55	50	
22	54	50	
23	55	50	
24	55	50	
25	54	50	
26	54	50	
27	54	50	
28	55	49	
29	55	50	
30	55	50	
31	55	50	
32	55	50	
33	55	50	
34	55	49	
35	55	50	
36	55	50	
37	54	50	
38	54	49	
39	55	49	
40	56	49	
41	56	49	
42	56	50	
43	57	50	
44	58	50	
45	58	50	
46	56	50	
47	56	50	
48	56	50	
49	56	50	
50	56	50	

Remarks: No problems were incurred.

Remarks: No problems were incurred.

Remarks: No problems were incurred.

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 1, 2, 3 and 4
 Load Weight: 18,000 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1 and 2
 Ambient Temperature (°F):
 High, 102; Low, 96
 Humidity (%): High, 32; Low, 28
 Soil Temperature (°F): High, 109; Low, 94

Gantry No. 1, 2, 3 and 4
 Load Weight: 20,000 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1 and 2
 Ambient Temperature (°F):
 High, 96; Low, 92
 Humidity (%): High, 71; Low, 54
 Soil Temperature (°F): High, 97; Low, 85

Gantry No. 1, 2, 3 and 4
 Load Weight: 22,300 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1 and 2
 Ambient Temperature (°F):
 High, 93; Low, 84
 Humidity (%): High, 64; Low, 60
 Soil Temperature (°F): High, 88; Low, 80

Pressure
Variation
Cycle No. Time (sec) Up Down Up Down Idle

Pressure
Variation
Cycle No. Time (sec) Up Down Up Down Idle

Pressure
Variation
Cycle No. Time (sec) Up Down Up Down Idle

Readings from Power Pack No. 2 only

Readings from Power Pack No. 2 only

Readings available from Power Pack No. 2 only

Cycle No.	Time (sec)	Up	Down	Up	Down	Idle
1	42	48	1300	1200	1700	
2	42	48				
3	42	48				
4	42	48				
5	42	48				
6	43	48				
7	42	47				
8	42	50				
9	42	50				
10	42	50				
11	42	50				
12	42	50				
13	43	50				
14	42	50				
15	42	50				
16	42	50				
17	42	50				
18	42	51				
19	42	50				
20	42	51				
21	43	51				
22	43	51				
23	42	50				
24	42	51				
25	42	51				
26	42	51				
27	42	52				
28	42	52				
29	42	51				
30	43	52				
31	42	52				
32	42	52				
33	43	51				
34	43	52				
35	42	51				
36	41	52				
37	41	52				
38	42	52				
39	42	52				
40	42	52				
41	43	53				
42	42	53				
43	43	52				
44	42	52				
45	43	53				
46	43	52				
47	42	52				
48	43	52				
49	42	52				
50	43	53				

Cycle No.	Time (sec)	Up	Down	Up	Down	Idle
1	43	48	1200	1200	1700	
2	42	48				
3	42	50				
4	42	50				
5	42	50				
6	43	48				
7	43	48				
8	43	48				
9	43	50				
10	43	49				
11	43	50				
12	44	50				
13	43	50				
14	43	50				
15	43	50				
16	43	50				
17	43	50				
18	43	50				
19	44	50				
20	44	50				
21	41	49				
22	44	50				
23	43	50				
24	43	50				
25	43	51				
26	43	51				
27	43	50				
28	43	51				
29	43	51				
30	43	51				
31	43	52				
32	43	51				
33	44	50				
34	44	51				
35	44	51				
36	44	52				
37	44	53				
38	43	54				
39	44	53				
40	43	53				
41	43	52				
42	44	52				
43	44	52				
44	43	52				
45	44	52				
46	44	52				
47	43	52				
48	44	52				
49	43	52				
50	43	52				

Cycle No.	Time (sec)	Up	Down	Up	Down	Idle
1	45	48	1300	1200	1700	
2	45	49				
3	45	50				
4	45	50				
5	45	49				
6	44	49				
7	44	50				
8	44	49				
9	44	50				
10	44	50				
11	44	48				
12	44	49				
13	45	50				
14	44	49				
15	44	49				
16	45	50				
17	44	49				
18	44	49				
19	45	50				
20	44	50				
21	45	50				
22	46	48				
23	44	48				
24	44	49				
25	45	49				
26	45	48				
27	45	48				
28	45	48				
29	45	48				
30	46	48				
31	45	48				
32	45	48				
33	45	48				
34	47	49				
35	44	50				
36	45	50				
37	46	50				
38	46	51				
39	48	51				
40	46	51				
41	47	51				
42	47	51				
43	48	51				
44	47	52				
45	47	52				
46	47	51				
47	47	52				
48	47	52				
49	46	52				
50	46	52				

Remarks: No problems were incurred.

Remarks: No problems were incurred.

Remarks: No problems were incurred.

TABLE 2. Mechanical Operation Data (Continued)

Gantry No. 1, 2, 3 and 4
Load Weight: 25,000 lb
Maximum Height Load Lifted: 62 in.
Power Pack No. 1 and 2
Ambient Temperature (°F):
High, 96; Low, 90
Humidity (%): High, 62; Low, 54

Gantry No. 1, 2, 3 and 4
 Load Weight: 27,500 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1 and 2
 Ambient Temperature (°F):
 High, 101; Low, 87
 Humidity (%): High, 54; Low, 50

Gantry No. 1, 2, 3 and 4
 Load Weight: 30,000 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1 and 2
 Ambient Temperature (°F):
 High, 98; Low, 92
 Humidity (%): High, 66; Low, 62
 Soil Temperature (°F): High, 89; Low, 88

Cycle No.	Time (sec)		Pressure Variation		
	Up	Down	Up	Down	Idle
Readings available from Power Pack					
No. 2 only					
1	49	50	1400	1200	1700
2	48	50			
3	46	49			
4	47	50			
5	47	50			
6	47	50			
7	48	50			
8	47	50			
9	46	50			
10	45	51			
11	46	50			
12	46	50			
13	47	51			
14	48	50			
15	47	51			
16	48	51			
17	49	51			
18	49	52			
19	49	51			
20	49	50			
21	47	48			
22	48	48			
23	47	49			
24	48	50			
25	47	49			
26	47	50			
27	47	50			
28	47	50			
29	48	50			
30	47	50			
31	48	50			
32	47	50			
33	47	51			
34	49	50			
35	48	50			
36	47	49			
37	49	50			
38	47	50			
39	47	50			
40	48	50	1300	1100	
41	48	50			
42	49	50			
43	48	49			
44	48	49			
45	47	50			
46	47	50			
47	47	50			
48	48	50			
49	47	51			
50	46	50			

Remarks: No problems were incurred.

Cycle No.	Time (sec)		Pressure Variation		
	Up	Down	Up	Down	Idle
Readings available from Power Pack No. 2 only					
1	48	50	1500	1200	1800
2	49	50			
3	49	50			
4	49	50			
5	49	49			
6	50	50			
7	52	50			
8	52	50			
9	53	49			
10	53	50			
11	53	51			
12	53	51			
13	53	50			
14	53	50			
15	54	50			
16	53	51			
17	53	50			
18	52	50			
19	52	50			
20	53	50	1400	1100	1700
21	53	51			
22	54	51			
23	54	51			
24	54	52			
25	54	51			
26	53	51			
27	53	51			
28	53	50			
29	53	51			
30	54	51			
31	54	51			
32	54	52			
33	54	52			
34	54	52			
35	54	52			
36	54	51			
37	54	51			
38	54	51			
39	54	52			
40	54	51			
41	54	51			
42	54	52			
43	54	51			
44	54	51			
45	54	51			
46	54	51			
47	54	51			
48	54	51			
49	54	51			
50	54	51			
					1200

Remarks: No problems were incurred.

Cycle No.	Time (sec)		Pressure Variation		
	Up	Down	Up	Down	Idle
Readings available from Power Pack No. 2 only					
1	52	49	1600	1200	1800
2	52	49			
3	52	49			
4	53	49			
5	51	49			
6	52	50			
7	52	49			
8	52	50			
9	53	50			
10	53	50			
11	52	50			
12	53	50			
13	53	50			
14	52	50			
15	53	50			
16	53	50			
17	54	50			
18	53	50			
19	54	50			
20	54	50	1400		1700
21	54	50			
22	54	50			
23	54	50			
24	54	50			
25	53	50			
26	53	50			
27	53	50			
28	53	50			
29	53	50			
30	53	51			
31	53	51			
32	53	51			
33	53	51			
34	53	52			
35	53	51			
36	53	52			
37	54	52			
38	55	51			
39	54	51			
40	54	52			
41	54	52			
42	54	52			
43	53	51			
44	53	51			
45	53	51			
46	53	51			
47	54	51			
48	54	51			
49	54	50			
50	54	51			

Remarks: No problems were incurred.

TABLE 2. Mechanical Operation Data (Concluded)

Gantry No. 1, 2, 3 and 4
 Load Weight: 32,500 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1 and 2

Gantry No. 1, 2, 3 and 4
 Load Weight: 35,000 lb
 Maximum Height Load Lifted: 62 in.
 Power Pack No. 1 and 2
 Ambient Temperature (°F):
 High, 56; Low, 94
 Humidity (%): High, 44; Low, 41
 Soil Temperature (°F): High, 91; Low, 88

Cycle No.	Time (sec)			Pressure Variation			Cycle No.	Time (sec)			Pressure Variation			
	Up	Down	Up	Down	Idle	Up	Down	Up	Down	Idle	Up	Down	Idle	
Readings available from Power Pack No. 2 only														
1	53	50	1600	1200	1800		1	54	49	1700	1100	1700		
2	53	50					2	54	51					
3	53	50					3	54	51					
4	53	50					4	54	50					
5	53	50					5	53	50					
6	52	51					6	53	51					
7	52	50					7	54	51					
8	53	50					8	54	51					
9	53	51					9	54	51					
10	53	50					10	53	51					
11	52	51					11	54	51					
12	53	51					12	54	51					
13	53	50					13	54	51					
14	53	50					14	54	50					
15	53	50					15	53	50					
16	52	50					16	54	50					
17	53	51					17	54	51					
18	53	50					18	54	50					
19	54	50					19	54	50					
20	53	50	1500	1100			20	54	51	1400				
21	54	51					21	54	50					
22	54	50					22	53	51					
23	54	51					23	53	51					
24	54	50					24	54	51					
25	54	50					25	54	51					
26	54	50					26	54	51					
27	54	50					27	54	50					
28	54	50					28	54	51					
29	54	51					29	53	51					
30	53	50					30	54	50					
31	54	50					31	54	51					
32	54	50					32	53	51					
33	54	50					33	53	50					
34	54	50					34	53	50					
35	54	50					35	54	51					
36	54	52					36	54	51					
37	54	51					37	54	51					
38	54	52					38	54	51					
39	54	50					39	54	51					
40	54	50	1400		1700		40	54	51					
41	55	50					41	55	50					
42	55	51					42	55	50					
43	55	50					43	54	50					
44	54	50					44	55	51					
45	54	50					45	55	51					
46	55	51					46	54	51					
47	54	50					47	54	51					
48	55	51					48	54	51					
49	55	52					49	55	51					
50	55	51					50	55	51	1600				

Remarks: No problems were incurred.

Remarks: No problems were incurred.

TABLE 3. Manual Operational Data

Load Wt (lb)	Max. Height Load Lifted (in.)	Time Required (min/sec)							
		Cycle 1		Cycle 2		Cycle 3		Up	Down
		Up	Down	Up	Down	Up	Down	Up	Down
3,000	76	3/14	2/5	3/35	2/20	3/30	2/15		
6,000	76	4/40	3/15	4/25	3/10	4/50	3/20		
9,000	76	5/45	3/0	6/20	3/10	6/10	3/5		
12,000	76	6/0	3/35	6/14	3/20	6/25	3/38		
15,000	76	9/20	3/48	9/40	3/55	9/25	3/50		
17,500	76	10/15	4/30	10/20	4/45	10/18	4/20		

TABLE 4. Radio Suppression Data

Item: Gantry Crane Power Pack
 Model: YAC32-1
 USA Reg No.: G000055
 Manufacturer: Continental Motors Corp

Specification: MIL-STD-461/462
 Test Date: 15 August 1968
 Test Area: 60 Percent Slope
 Test Equipment: AN/URM 85

Radiation Test - DS* Class III C

Freq Mcs	A	P	a	Freq Mcs	A	P	a
0.15	71+	89	71+	110	25	58	47
0.35	71+	85	71+	120	27	57	49
1.5	71+	78	71+	130	28	57	54
3	71+	75	71+	140	31	56	58
5	57	72	59	150	34	56	52
8	58	70	61	160	35	56	58
12	63	68	63	170	34	56	54
16	65	67	65	180	34	55	45
20	40	65	53	190	33	55	44
23	43	65	49	200	31	55	48
27	51	64	51	220	30	55	53
30	33	64	51	240	20	56	71+
35	38	63	49	260	20	57	71+
38	35	63	51	280	23	58	71+
40	33	62	51	300	35	58	71+
45	30	62	52	350	26	60	71+
50	28	61	59	400	23	61	71+
55	31	61	53				
60	36	61	44				
65	33	60	39				
70	46	60	45				
75	45	59	57				
80	39	59	45				
85	33	59	48				
90	32	58	52				
95	32	58	49				
100	31	58	48				

*Decibels above one microvolt per megacycle of bandwidth

A - Ambient noise level

P - Passing limit

a - Interference noise level at ambient

Remarks: As specified in MIL-STD-461; the limit for class IIIC items in the applicable frequency range of 0.15 to 400 MHz shall be relaxed by 20 db.

APPENDIX II. FINDINGS

<u>Requirements</u>	<u>Source</u>	<u>Degree of Compliance</u>
Individual components of the system shall be sufficiently lightweight to enable carrying for short distances and loading by four men onto a military vehicle.	Paragraph 2c, AMCTCM Approved TC	Did not meet requirement (Test No. 1 and Para. 1.1 App III).
No component or group of components of the system shall be of such a size as to prevent air transport by cargo aircraft in accordance with applicable portions of Appendices A and B of AR 705-35.	Paragraph 2m, AMCTCM Approved TC	Met requirement (Test No. 1).
Component parts of the system must comply with the requirements of approved specifications (federal, military and/or industry), and be made corrosion resistant through use of applicable standard methods and materials.	Paragraph 2o, AMCTCM Approved TC	Did not meet requirement (Test No. 1 and Para. 2.1, App III).
The device must have a lifting capacity of 17,500 pounds and when used in pairs as a system must be capable of lifting a load measuring 108 inches high, 110 inches wide, and 336 inches long, weighing 35,000 pounds, to a height which will provide a 60-inch ground clearance and will permit placement onto a ground transport vehicle up to 120 inches in width.	Paragraph 2a, AMCTCM Approved TC	Met requirement (Test No. 2).
The system must be capable of manual assembly from shipping to operational condition, without special tools or materials handling equipment. Assembly time for a device (17,500-lb capacity) from removal from shipping skids to erection must be less than 1 hour, when using four men.	Paragraph 2b, AMCTCM Approved TC	Met requirement (Test No. 2).

<u>Requirement</u>	<u>Source</u>	<u>Degree of Compliance</u>
The system must have mechanical leveling provisions to insure stability in all directions for all loads up to rated load on sloping terrain up to and including 5-degree slopes.	Paragraph 2c, AMCTCM Approved TC	Met requirement (Test No. 2).
The device, when assembled, must be capable of being man-propelled short distances over unsurfaced and non-trafficked areas in the vicinity of forward airfields.	Paragraph 2f, AMCTCM Approved TC	Requirement compliance could not be determined (Test No. 2).
The system must be capable of raising the rated load to a 60-inch height in approximately 120 seconds, using self-contained gasoline engine operated power packages, together with hydraulic control and lift components.	Paragraph 2g, AMCTCM Approved TC	Met requirement (Test No. 2).
The device shall be operable from a single control station.	Paragraph 2h, AMCTCM Approved TC	Met requirement (Test No. 2).
The system must be capable of manual operation if power is not available. With manual operation, the lift rate requirement of above is not mandatory.	Paragraph 2i, AMCTCM Approved TC	Met requirement (Test No. 2).
The system must meet the requirements of the current revision of Specification MIL-T-11748 (Signal Corps), "Interference Reduction for Electrical and Electronic Equipment."	Paragraph 2p, AMCTCM Approved TC	Met requirement (Test No. 2).
The system, when operated by its hydraulic power package, shall demonstrate with 95 percent reliability the capability of performing a daily mission. A daily mission is defined as a total of 50	Paragraph 2b15, AMCTCM, Approved Operational Characteristics and verbal request by Natick Labs.	Met requirement (Test No. 3).

<u>Requirement</u>	<u>Source</u>	<u>Degree of Compliance</u>
<p>cycles (lifts of various load weights within the rated capacity. This implies 20 mission days as Mean Time Between Failures (MTBF). A failure is defined as that which prevents the unit from completing its assigned mission and cannot be repaired by the operator with the tools and materials provided within 30 minutes.</p> <p>Unscheduled organizational maintenance should not exceed 30 minutes during the performance of a daily mission. The total maintenance manhours will not exceed 10 percent of the operating hours on the basis of 8 hours of operation equal to 1 mission day. Total maintenance will include scheduled and unscheduled maintenance from operator level through direct support level.</p>		
<p>The system must be capable of statically supporting twice the rated load without evidence of permanent deformation, when loaded at an attitude to 3 degrees in any direction from the vertical.</p>	Paragraph 2j, AMCTCM Approved TC	Not tested.
<p>The system must demonstrate sufficient reliability and durability to lift 150 percent of its rated load to its fully raised height of 60 inches, for 50 cycles, with all overload safety devices rendered inoperable for duration of test.</p>	Paragraph 2k, AMCTCM Approved TC	Not tested.
<p>The system must be easily maintained under field conditions. Components must be interchangeable between like items of the system. Maintenance costs must be a minimum for systems of this type.</p>	Paragraph 2l, AMCTCM Approved TC	Met requirement (Test No. 3).

<u>Requirement</u>	<u>Source</u>	<u>Degree of Compliance</u>
The system must be capable of operation and storage in temperatures from -65°F to +125°F.	Paragraph 2r, AMCTCM Approved TC	Not completely determined (Test No. 3).

APPENDIX III. DEFICIENCIES AND SHORTCOMINGS

1. Deficiencies

<u>Deficiency</u>	<u>Suggested Corrective Action</u>	<u>Remarks</u>
1.1 One of the basic components of the gantry, the power pack, was too heavy to enable carrying for short distances and loading by four men onto a military vehicle.	None	If hydraulic oil were drained from power pack, weight would be within criteria.

2. Shortcomings

<u>Shortcoming</u>	<u>Suggested Corrective Action</u>	<u>Remarks</u>
2.1 The manual chain hoist chains corroded during testing.	Coat chains with non-corrosive material.	None
2.2 Baseplate wrench failed to operate properly.	Closer quality control be observed.	None
2.3 Oil seepage from hydraulic oil cylinder seals.	Better grade seals be used.	None

3. Suggested Improvements

<u>Quality/Performance</u>	<u>Suggested Action</u>	<u>Remarks</u>
3.1 Broken pressure gages.	Observe gages during service testing. If gages continue to fail, investigate possibility of replacement with a gage which will withstand high transient oil pressure.	None
3.2 Cable ends of the winch hoist cable are clamped and the loose ends taped. After 3 or 4 weeks the tape falls off and the wire cable is exposed which is a safety hazard.	Solder loose ends of cable.	None
3.3 Lifting loads with the manual chain hoist for 1 hour will cause blisters and open wounds on a man's hands.	Issue protective gloves to be worn when operating the manual chain hoist.	None

<u>Quality/Performance</u>	<u>Suggested Action</u>	<u>Comments</u>
3.4 Shipping tape was wrapped around the winch hoist breast handles during shipment. During assembly of the test item, a small piece of tape was not removed between the winch hoist handle washer and the winch hoist, causing the safety brace to slip.	As small pieces of tape are easy to overlook and may create a safety hazard it is suggested that all loose ends be tied (rather than taped) to the frame for shipment.	None
3.5 Shipping containers are poorly constructed.	Redesign shipping containers. None	

APPENDIX IV. MAINTENANCE EVALUATION

TABLE I. Maintenance Data

Quantity	Components and Related Operations	Maintenance Time	Operation	Maint. Change	Type	Remarks
1 to 2	Manifold hose quick fit disconnects (adjusted)	30 min	2 hr	Unscheduled	Oil leak (EPR L5-2)	
1 to 2	Oil maintenance	15 min	2 hr	Unscheduled	Lubrication and inspection of power pack.	
3 to 4	Manifold hose quick fit disconnects (tightened)	5 min	2 min	Unscheduled	Oil leak (EPR L5-4).	
3 to 4	Manifold hose quick fit disconnects (tightened)	3 min	10 min	Unscheduled	Oil leak (EPR L5-4).	
4 to 4	Manifold hose quick fit disconnects (repaired)	5 min	10 min	Unscheduled	Oil leak (EPR L5-4).	
3 to 4	Hose assembly (adjusted)	3 min	1 hr	Unscheduled	Hose off shelves (EPR L5-5).	
3 to 4	Hose assembly (adjusted)	12 min	2 hr to 3 hr 20 min	Unscheduled	Hose off shelves - Replaced 6 times - then disregarded (EPR L5-5-2).	
3 to 4	Hose assembly (repaired)	30 min	3 hr 20 min	Unscheduled	Oil leak (EPR L5-6).	
						(NOTE: Repair created a hazardous condition - item was then replaced. min)
3 to 4	Pressure gauge (replaced)	5 min	11 hr 7 min	Unscheduled	Broken pressure gauge (EPR L5-7).	

TABLE 1. Maintenance Data (Concluded)

Unitry No.	Component and Related Operations	Active Maintenance Time	Life	Type Maintenance	Remarks
3 & 4	Pressure gage (replaced)	5 min	10 hr 2 min	Unscheduled	Broken pressure gage (EPR L5-7-2).
3 & 4	Pressure gage (replaced)	5 min	20 hr 32 min	Unscheduled	Broken pressure gage (EPR L5-7-2).
3 & 4	Cylinder fitting connections (tightened, could not be repaired).	0 min	20 hr	Unscheduled	Oil leak (EPR L5-8).
3 & 4	Ork maintenance	15 min	25 hr	Scheduled	Lubrication and inspection of power pack.

TABLE 2. Maintenance Times

<u>Nomenclature</u>	<u>Gantry</u> <u>1 and 2</u>	<u>Gantry</u> <u>3 and 4</u>	<u>Total</u> <u>System</u>
Operating hours	44.5	46.7	91.2
Active maintenance hours*	0.4	1.3	1.7
Maintenance ratio	0.009	0.028	0.019
Mean time between failures	44.5	46.7	91.2

*Includes unscheduled and scheduled inspection time.

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APPENDIX V. PHOTOGRAPHS

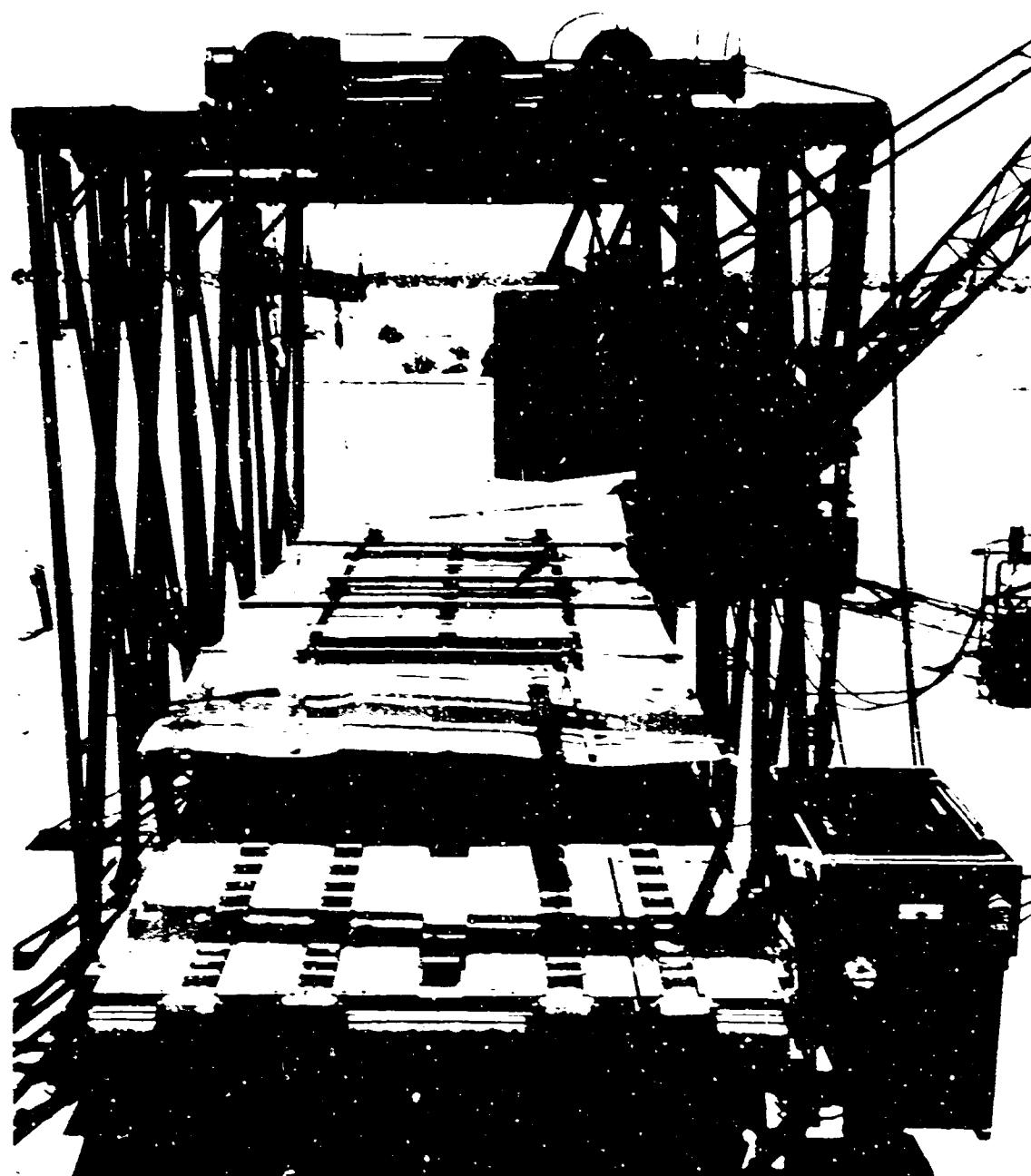


FIGURE 1. Aircraft loader (120 inches wide) driven under gantry system to pick up a 35,000-pound load which was extended to measure 336 inches long and 110 inches wide.



FIGURE 2. Man's hands after operating manual chain hoist for a period of 1 hour. Note blisters and open wounds.

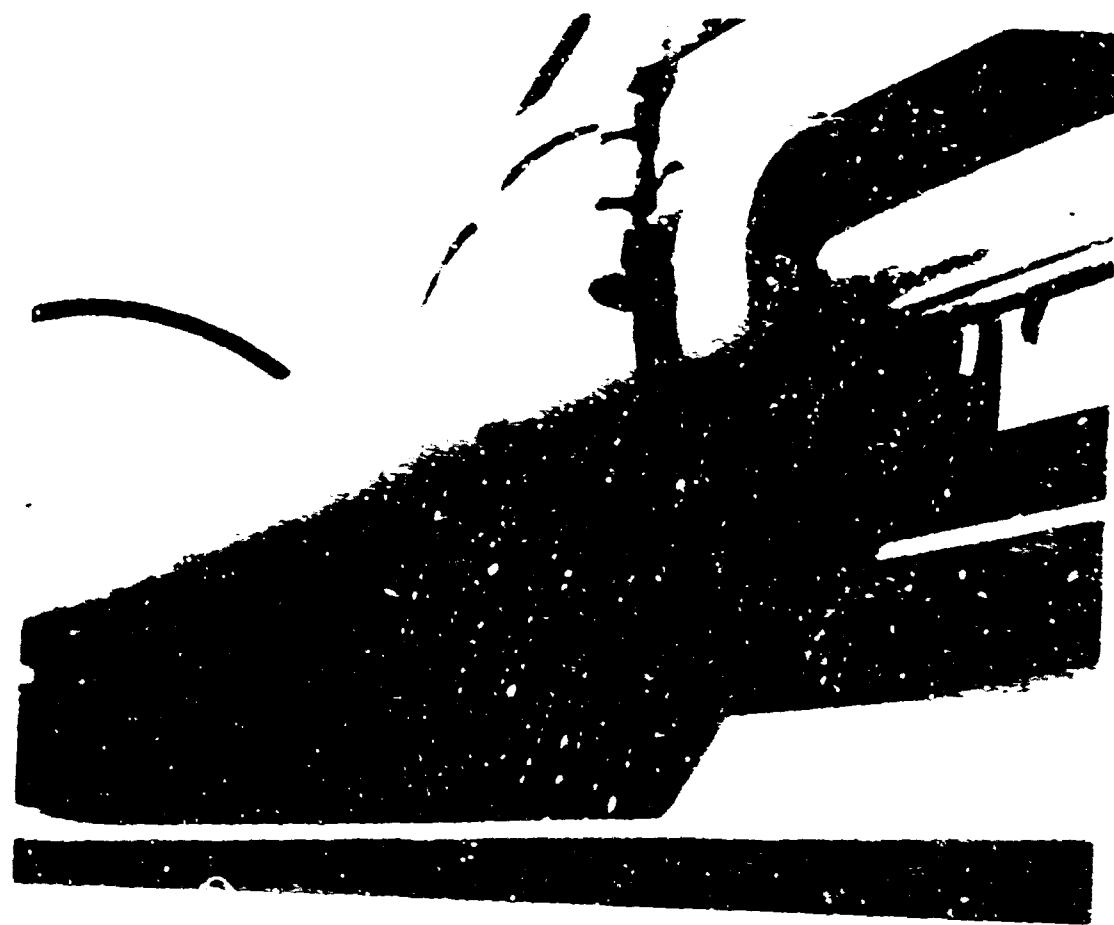


FIGURE 3. Hydraulic cylinder showing oil leakage from seals.

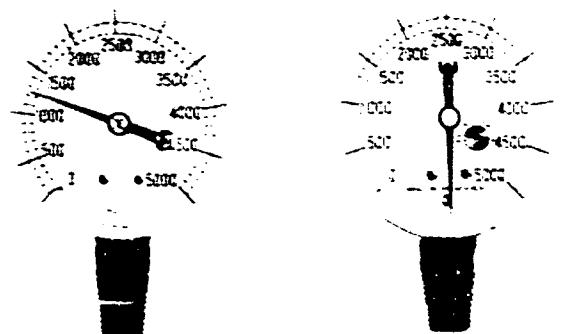
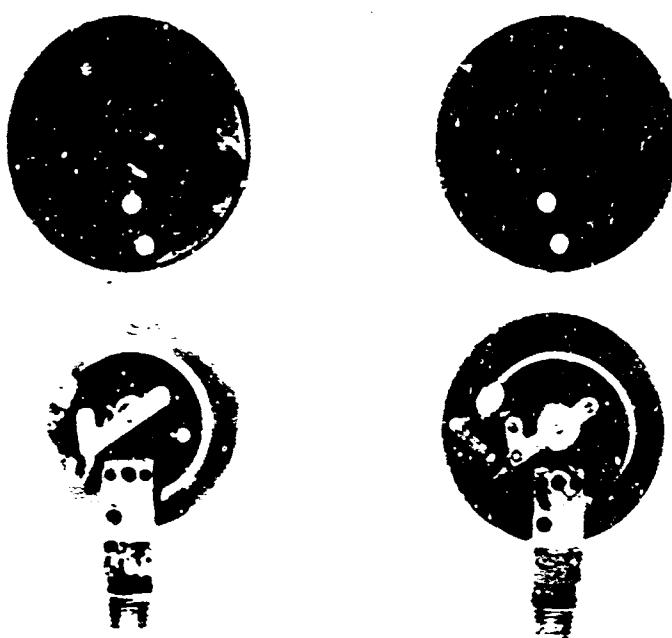


FIGURE 4. Broken gages which were replaced on the power pack during testing. At left, gage with the brass movement (note shavings). Gage wore thin. At right, gage with bronze movement. Gage broke.

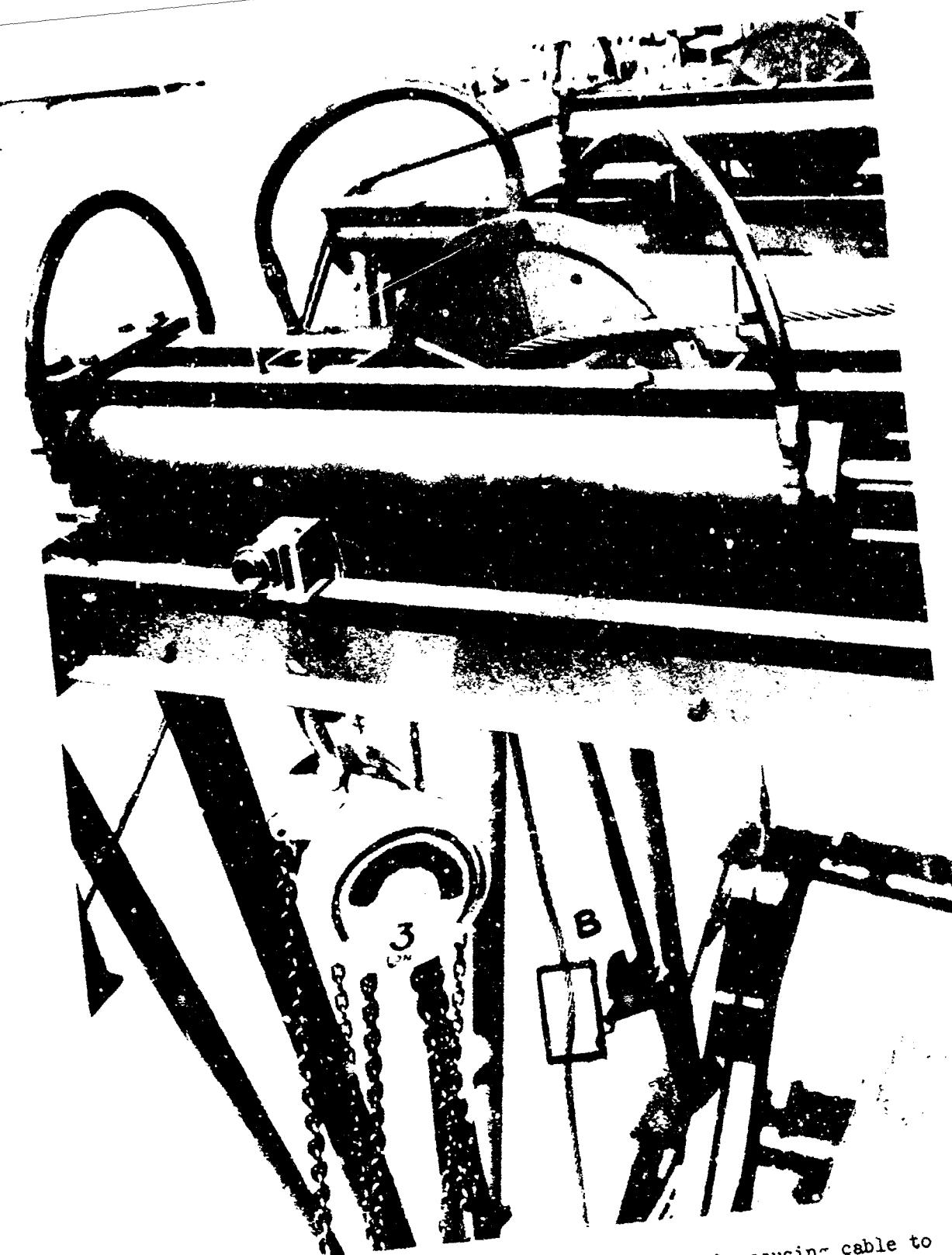


FIGURE 5. Load was lifted at a 3.0-degree angle causing cable to jump off sheave (Item A) and to kink (Item B).



FIGURE 6. Cable ends of winch hoist cable.

APPENDIX VI. REFERENCES

1. Letter, AMSTE-BG, USATECOM, subject "Test Directive for Service Test of Gantry, Lightweight, Airdrop Rigging," 28 July 1966.
2. Letter, U.S. Army Natick Laboratories, subject "Preliminary Report of Engineering Design Test of Gantry, Lightweight, Airdrop Rigging," June 1966.
3. Letter, U.S. Army Natick Laboratories, subject "Revised Copy of Small Development Requirement and Technical Characteristics of Subject Gantry, as Amended by Minutes of In-Process Review Meeting, and as Approved by Indorsement from Hq, DA, OCRD," May 1968.
4. TM 5-2805-203-14, dated April 1965.
5. Letter, U.S. Army Natick Laboratories, subject "Gantry, Lightweight, Airdrop Rigging," 15 August 1968.
6. Maintenance and Operating Manual for the Portable Lightweight Lifting System for Preparation of Airdrop Cargoes, dated 7 March 1966.
7. U.S. Army Mobility Equipment Center, Draft Operator, Organizational, Direct and General Support Maintenance Manual (DTM 5-3950-205-14) for Gantry, Lightweight System for Preparation of Airdrop Cargoes, PSN (None Assigned), Natick Project NL-92.1, updated to March 1968.
8. USATECOM Regulation 385-2, Safety Responsibilities, 18 February 1963.
9. U.S. Army Airborne, Electronics and Special Warfare Board, subject "Service Test of Gantry, Lightweight, Airdrop Rigging, RDTE Project No. 1M141812D18322A, USATECOM Project No. 4-5-7491-01 (AB 767)," June 1967.
10. USATECOM Regulation 385-7, Safety Confirmation, 18 December 1962.
11. USATECOM Regulation 700-1, Value Analysis in Materiel Testing, 18 February 1967.

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13. ABSTRACT The engineer test of the Gantry, Lightweight, Airdrop Rigging, was conducted by Yuma Proving Ground from 20 May 1968 to 30 August 1968. The purpose of the test was to determine the suitability of the test gantry for service testing. All testing was conducted under natural environmental conditions. The approved technical characteristics of the test item were used as criteria to determine test item reliability. The power pack was too heavy for four men to carry and load onto a military vehicle (deficiency). The manual chain hoists corroded, the winch broke, and the hydraulic cylinder leaked oil (shortcomings). It was concluded that the shortcomings were readily correctible. It was also concluded that if only four men are available the hydraulic oil could be drained from the power pack, thus eliminating the heavy weight deficiency. It was recommended that the Gantry, Lightweight, Airdrop Rigging be subjected to service testing.		

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